Software Product Lines Essentials

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Report Documentation Page

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Today's Session

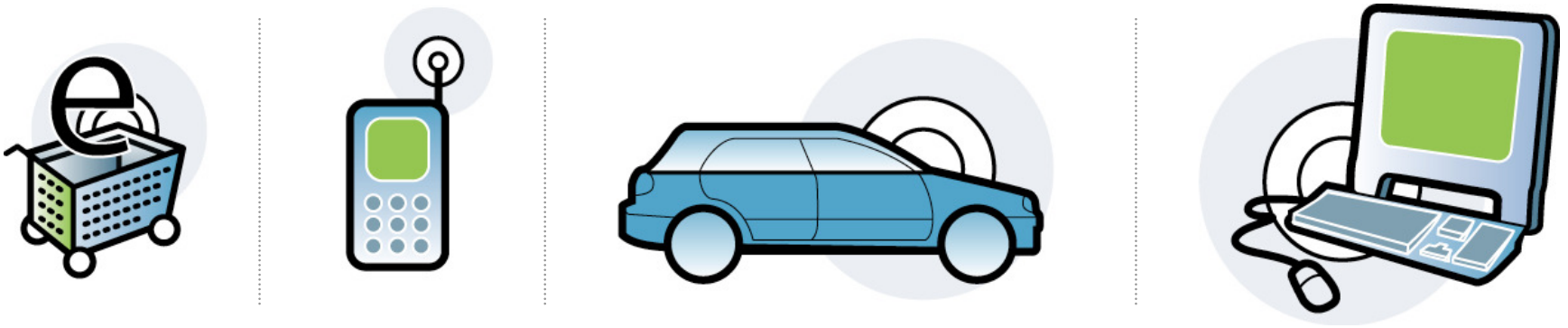
Introduction

Product Line Concepts

- What
- Why
- How

Conclusion

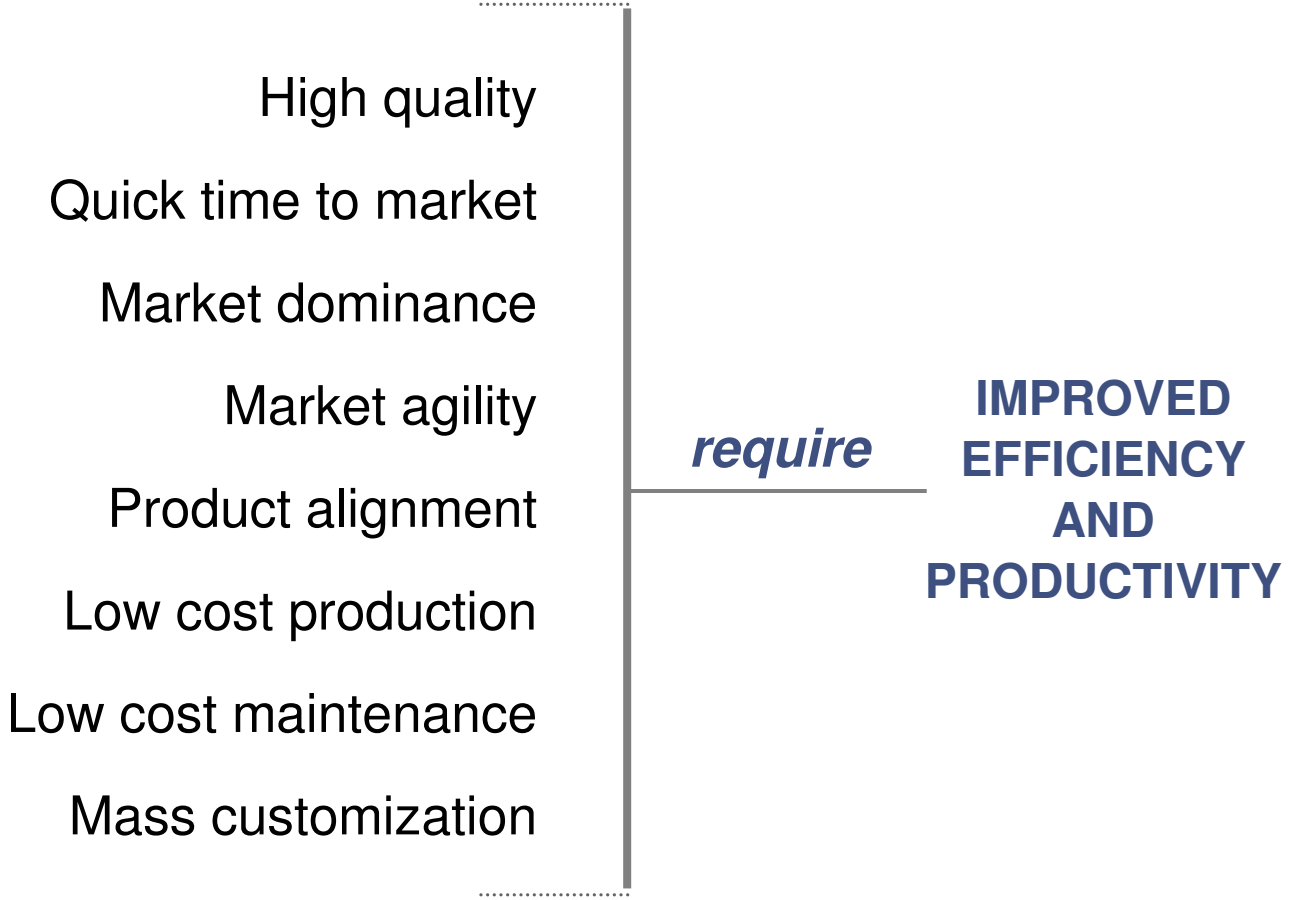
Business Success Requires Software Prowess



Software pervades every sector.

Software has become the bottom line for many organizations, even those who never envisioned themselves in the software business.

Universal Business Goals

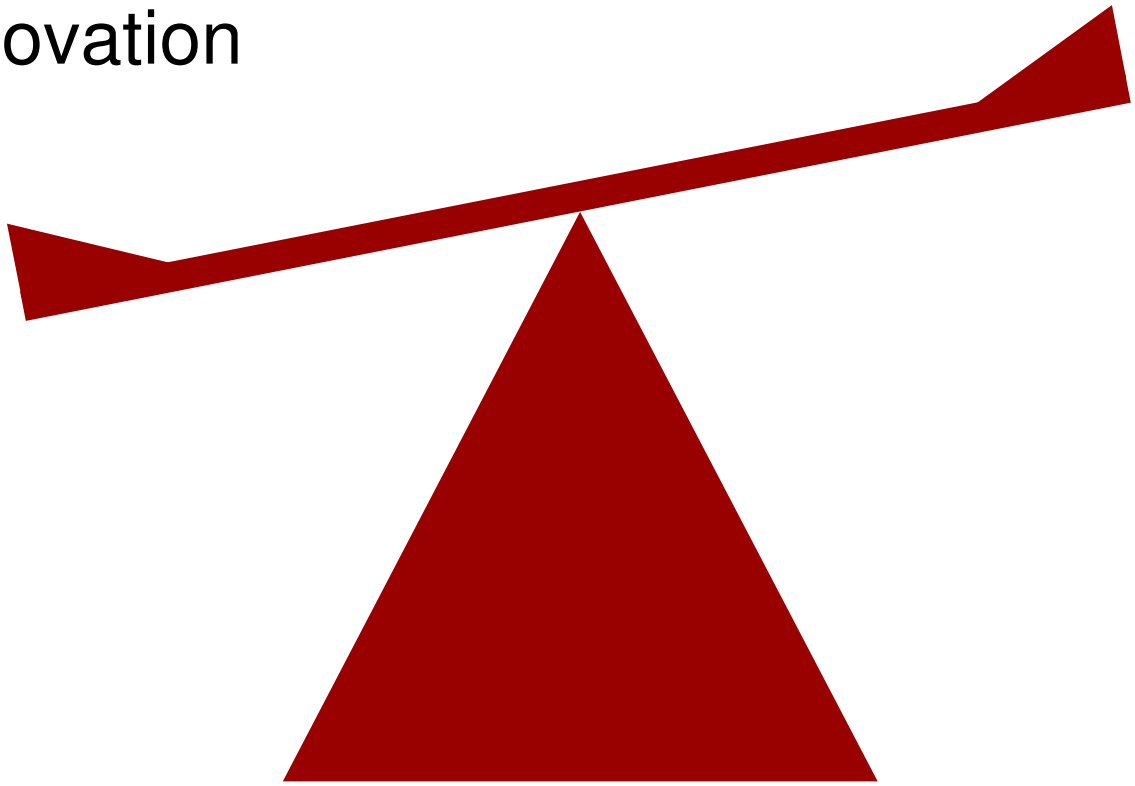


Software (System) Strategies

Process improvement

Technology innovation

Reuse



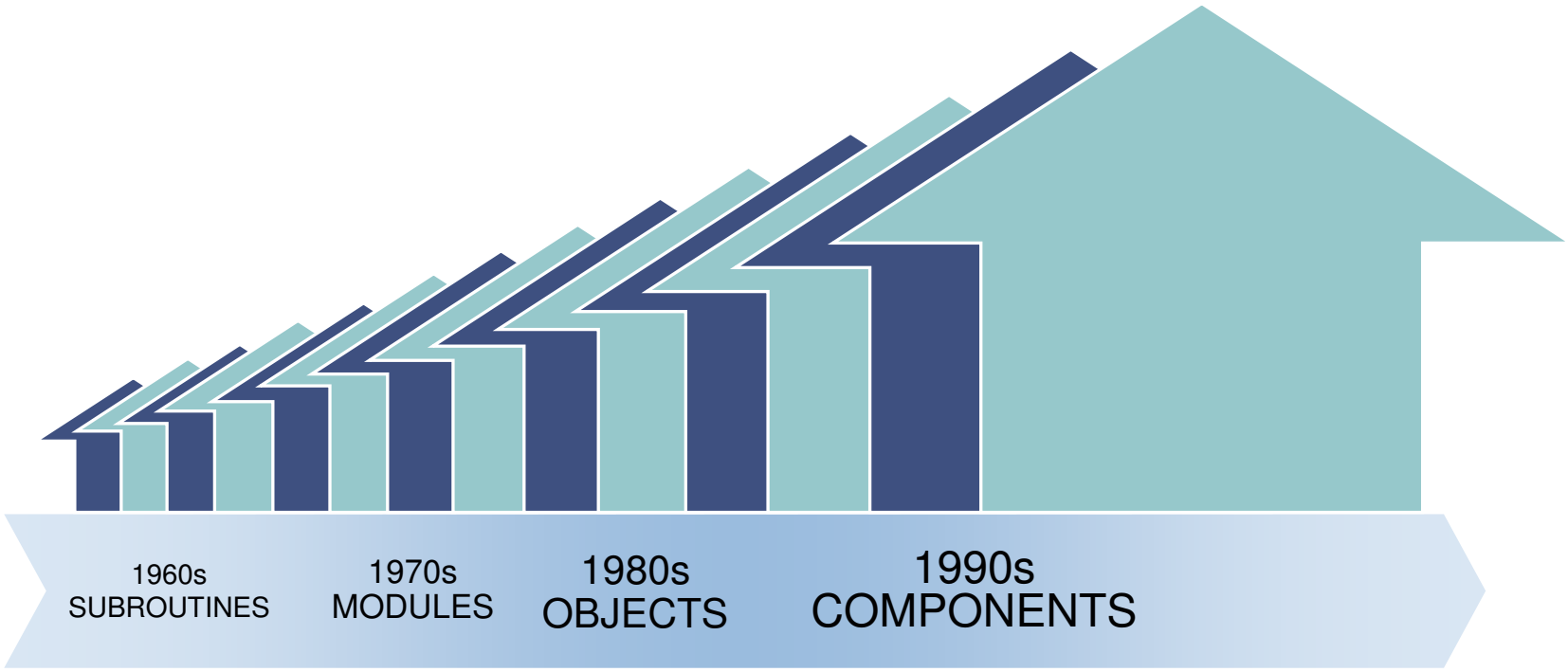
Few Systems Are Unique

Most organizations produce families of similar systems, differentiated by features.

A reuse strategy makes sense.

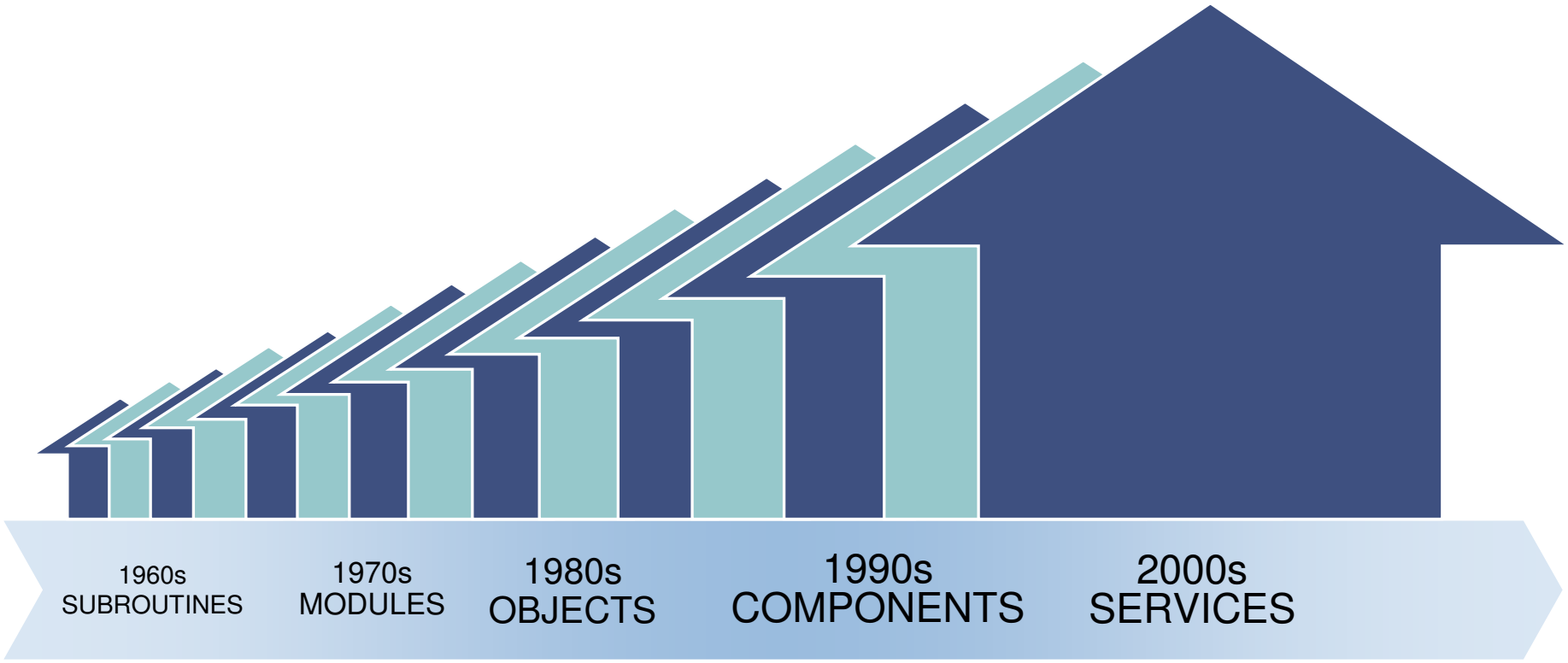
Traditional reuse strategies have had little economic benefit.

Reuse History

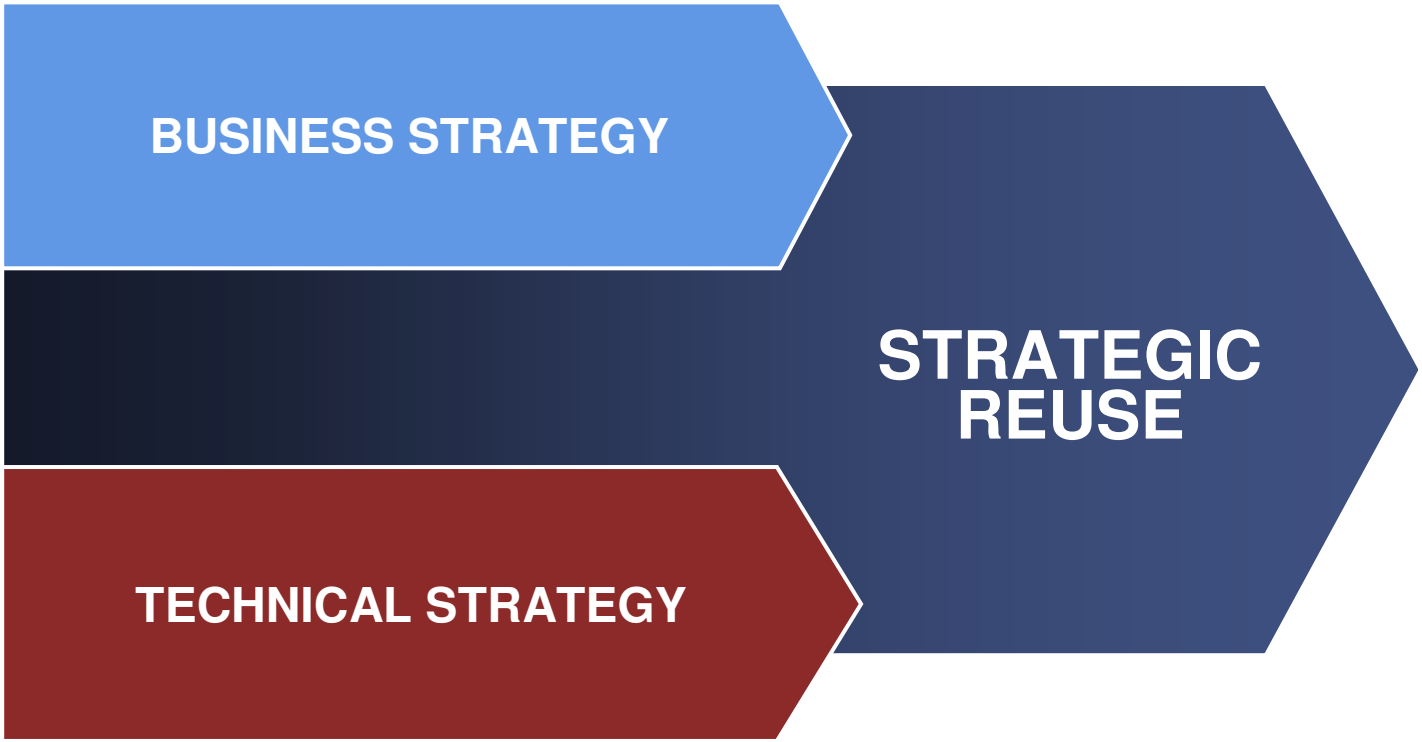


Focus was small-grained, opportunistic, and technology-driven.
Results did not meet business goals.

Reuse History



Strategic Reuse is Needed for Business Benefits



Celsiustech: Ship System 2000

A family of 55 ship systems

- Need for developers dropped from 210 to roughly 30.
- Time to field decreased from about 9 years to about 3 years.
- Integration test of 1-1.5 million SLOC requires 1-2 people.
- Rehosting to a new platform/OS takes 3 months.
- Cost and schedule targets are predictably met.

Cummins Inc.: Diesel Control Systems

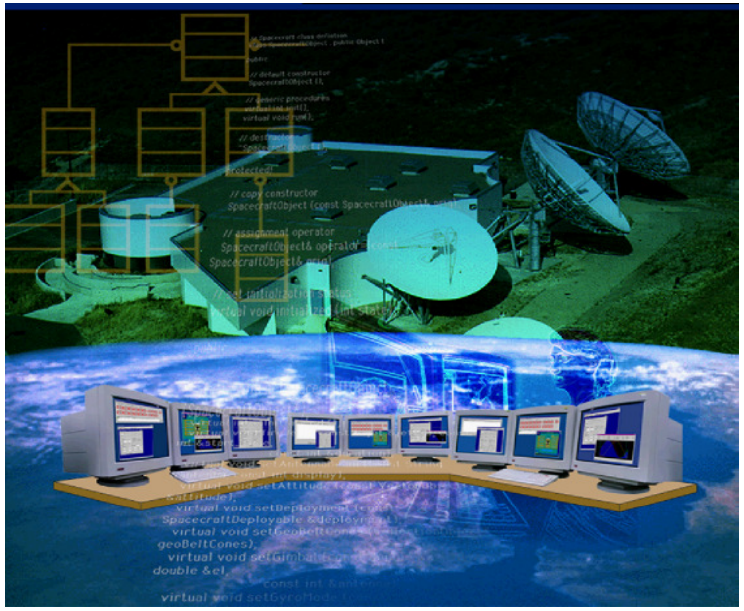
Over 20 product groups with over 1,000 separate engine applications

- Product cycle time was slashed from 250 person-months to a few person-months.
- Build and integration time was reduced from one year to one week.
- Quality goals are exceeded.
- Customer satisfaction is high.
- Product schedules are met.

National Reconnaissance Office/ Raytheon: Control Channel Toolkit

Ground-based spacecraft command and control systems

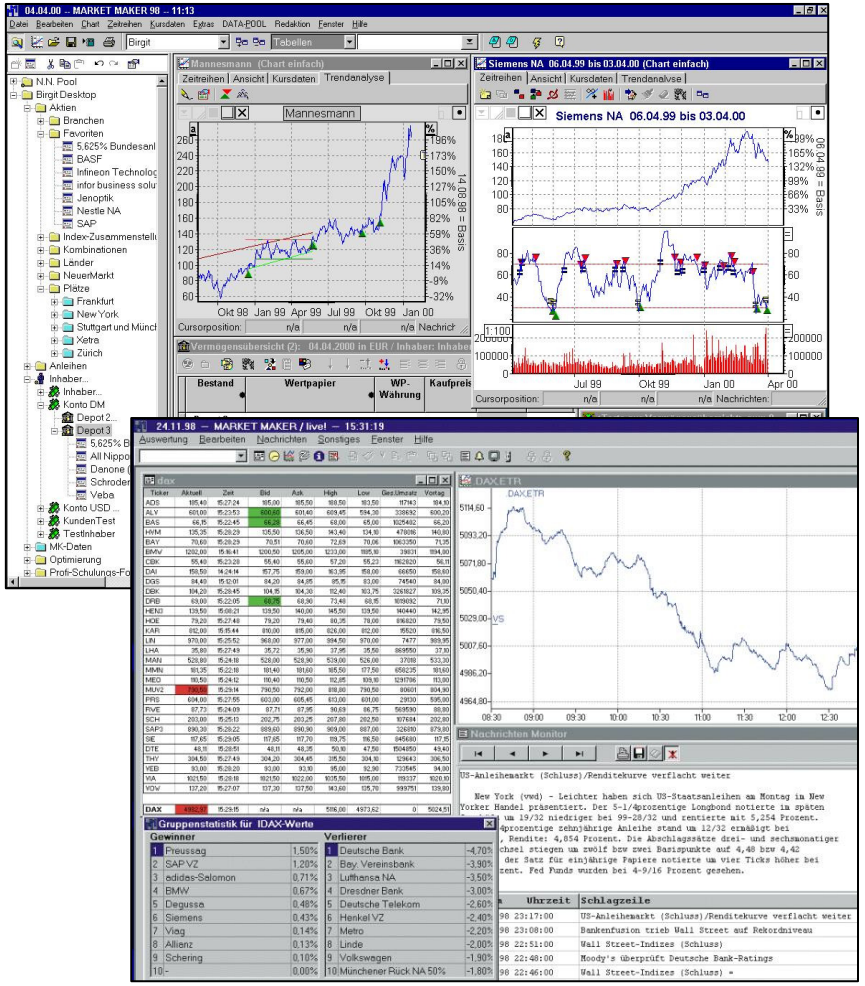
- First system had 10 times fewer defects than usual.
- The incremental build time was reduced from months to weeks.
- The system development time and costs decreased by 50%.
- There was decreased product risk.



Market Maker GMBH: Merger

Internet-based stock market software

- Each product is “uniquely” configured.
- Putting up a customized system takes three days.



Nokia Mobile Phones

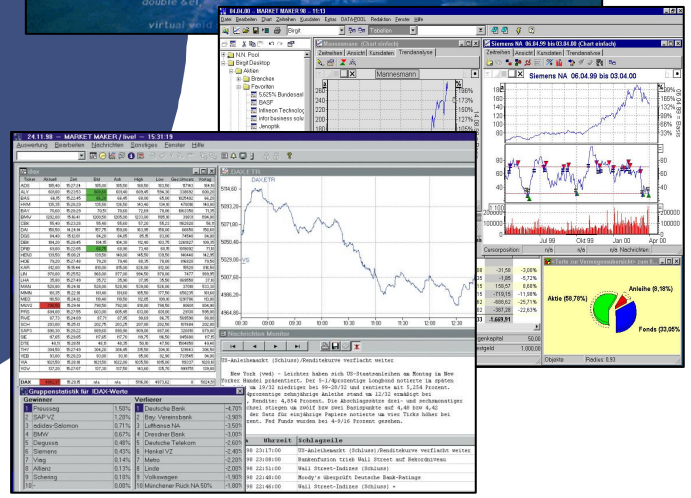
Product lines with 25-30 new products per year versus 5 per year originally.

Across products there are

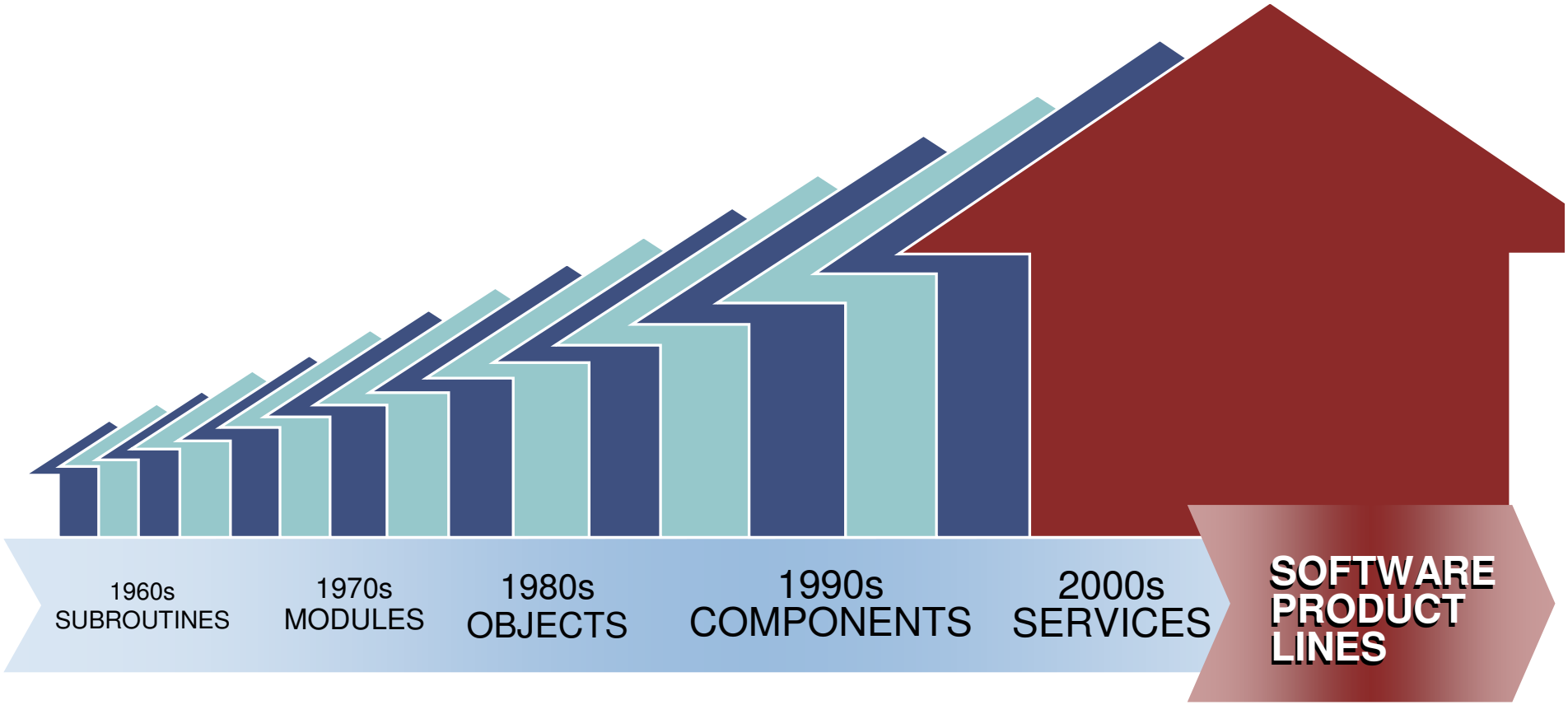
- varying number of keys
- varying display sizes
- varying sets of features
- 58 languages supported
- 130 countries served
- multiple protocols
- needs for backwards compatibility
- configurable features
- needs for product behavior
- change after release

How Did They Do It?

SOFTWARE PRODUCT LINES



Reuse History: From Ad Hoc To Systematic



Today's Session

Introduction

Product Line Concepts

- ***What***
- Why
- How

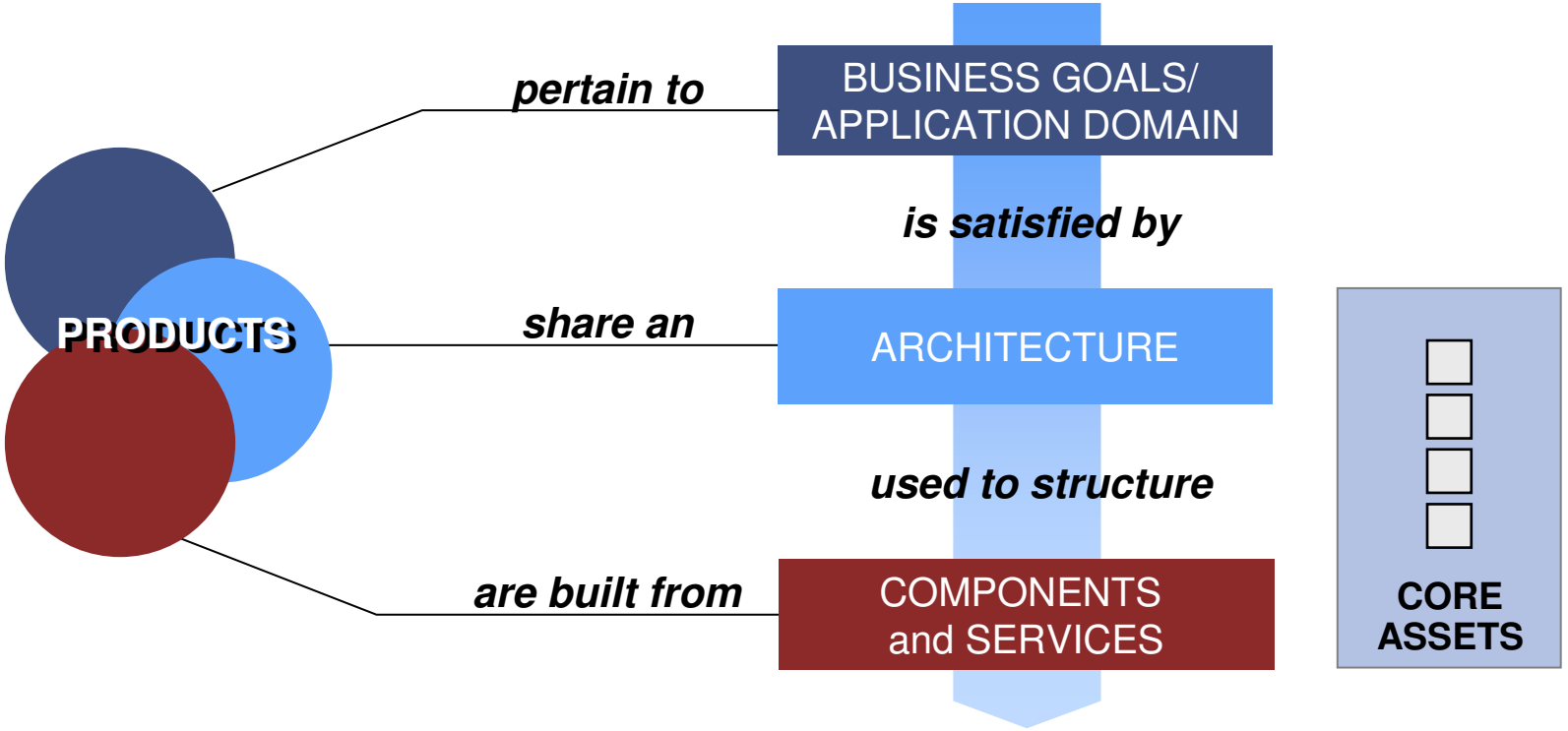
Conclusion

What Is A Software Product Line?

A *software product line* is a set of software-intensive systems sharing a common, managed set of features that satisfy the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way.

- a new application of a proven concept
- an innovative, growing concept in software engineering

Software Product Lines

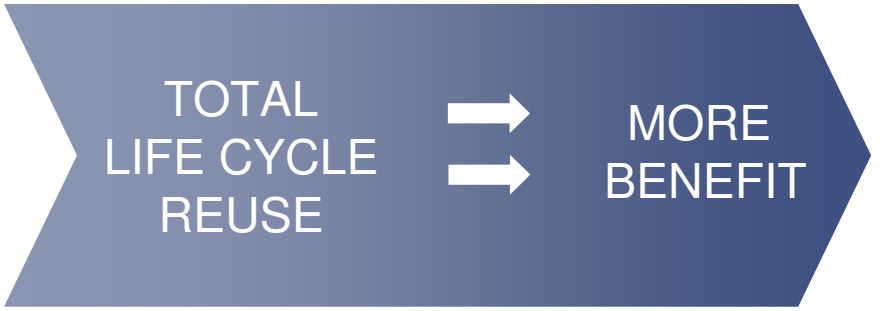


Product lines
- take economic advantage of commonality
- bound variation

How Do Product Lines Help?

Product lines amortize the investment in these and other *core* assets:

- requirements and requirements analysis
- domain model
- software architecture and design
- performance engineering
- documentation
- test plans, test cases, and test data
- people: their knowledge and skills
- processes, methods, and tools
- budgets, schedules, and work plans
- components and services



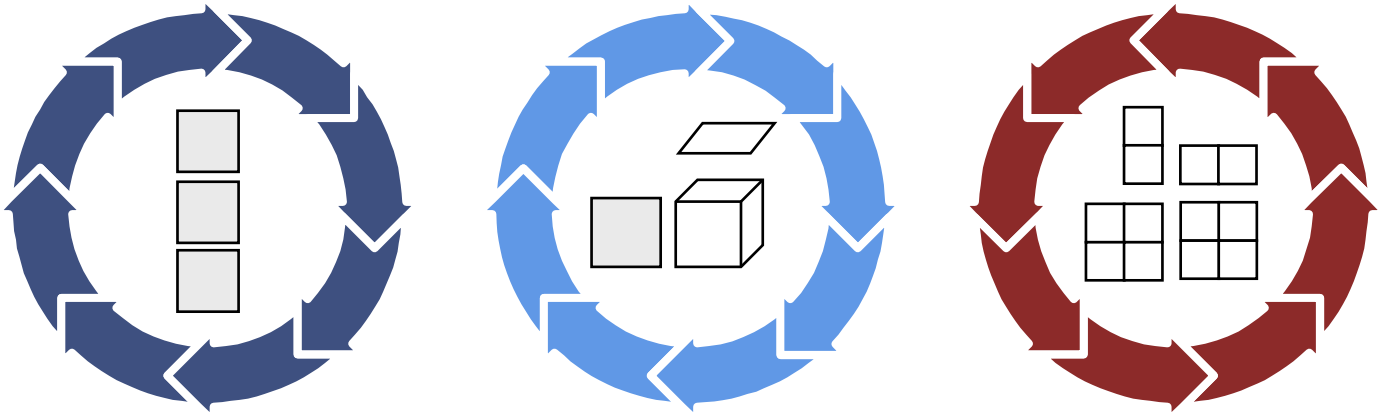
PRODUCT LINES = STRATEGIC REUSE

The Key Concepts

Use of a core asset base

in production

of a related set of products



The Key Concepts

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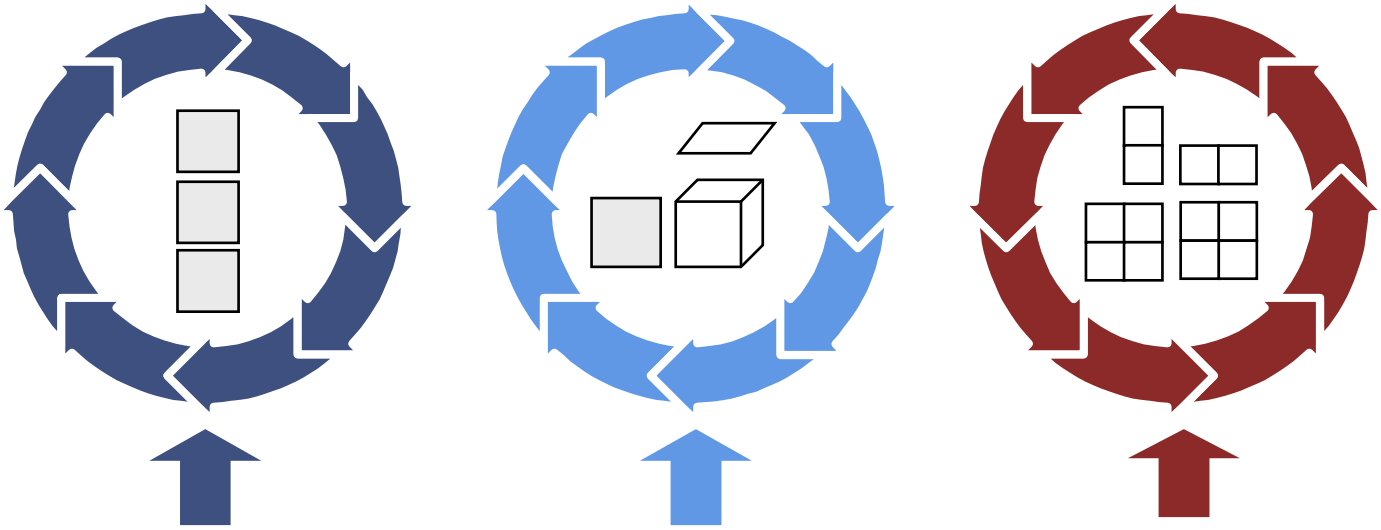


Architecture

Production Plan

Scope Definition
Business Case

Software Product Lines Are Not

Clone and own: single-system development with reuse

- modifying code as necessary for the single system only

Fortuitous small-grained reuse

- reuse libraries containing algorithms, modules, objects, or components

Just component-based or service-based development

- selecting components or services from an in-house library, the marketplace, or the Web with no architecture focus

Just versions of a single product

- rather, simultaneous release and support of multiple products

Just a configurable architecture

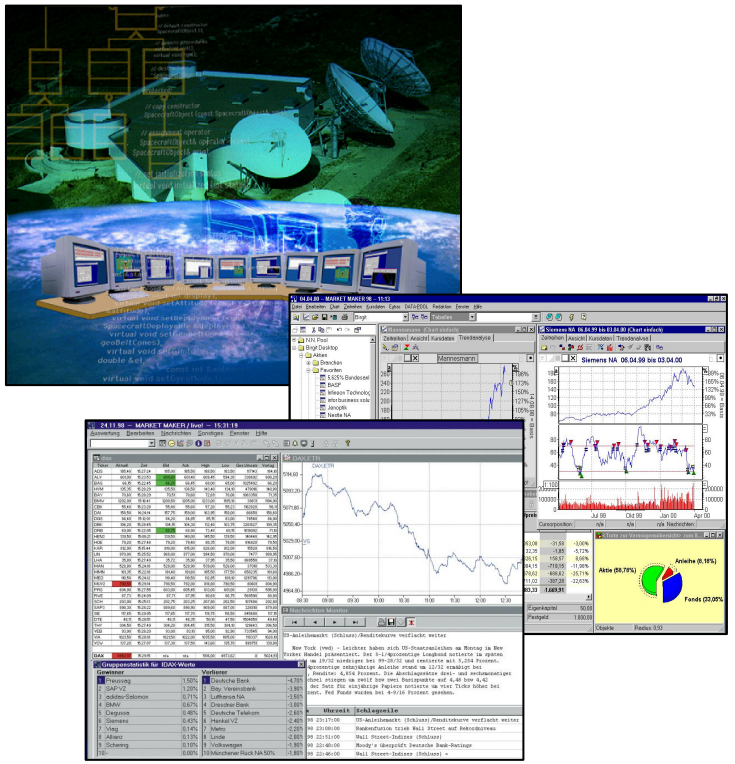
- a good start, but only part of the reuse potential

Just a set of technical standards

- constraining choices without an architecture-based reuse strategy

Software Product Lines Are

Software product lines involve strategic, planned reuse that yields predictable results.



Widespread Use of Software Product Lines

Successful software product lines have been built for families of among other things

- mobile phones
- command and control ship systems
- satellite ground station systems
- avionics systems
- command and control/situation awareness systems
- pagers
- engine control systems
- mass storage devices
- billing systems
- web-based retail systems
- printers
- consumer electronic products
- acquisition management enterprise systems
- financial and tax systems
- medical devices
- farm fish management software

Specific Examples - 1

akvasmart

Feed control and farm management software

BOEING

Bold Stroke Avionics

E-COM Technology Ltd.

Medical imaging workstations

hp invent

Firmware for computer peripherals

Lucent Technologies
Bell Labs Innovations

5ESS telecommunications switch

ABB **Asea Brown Boveri**

Gas turbines, train control, semantic graphics framework

Dialect

Internet payment gateway infrastructure products

ERICSSON

AXE family of telecommunications switches

LG

Elevator control systems

NOKIA

Mobile phones, mobile browsers, telecom products for public, private and cellular networks

AXIS COMMUNICATIONS

Computer printer servers, storage servers, network camera and scanner servers

DNV

Customized solutions for transportation industries

GM

Software for engines, transmissions and controllers

LSI LOGIC

RAID controller firmware for disk storage units

NASA

Interferometer product line

Specific Examples - 2

PHILIPS

High-end televisions, PKI telecommunications switching system, diagnostic imaging equipment

Rockwell Collins

Commercial flight control system avionics, Common Army Avionics System (CAAS), U.S. Army helicopters

symbian

EPOC operating system

NAVSEA WARFARE CENTERS

Test range facilities

RICOH

Office appliances

SALION TARGET. WIN. DELIVER.

Revenue acquisition management systems

TELVENT

Industrial supervisory control and business process management systems

U.S.ARMY

Command and control simulator for Army fire support

BOSCH

Automotive gasoline systems

SIEMENS

Software for viewing and quantifying radiological images

testo

Climate and flue gas measurement devices

alltel FIDELITY NATIONAL FINANCIAL

Support software

MOTOROLA

Pagers product line

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Real World Motivation

Organizations use product line practices to:

- achieve large scale productivity gains
- improve time to market
- maintain market presence
- sustain unprecedented growth
- achieve greater market agility
- compensate for an inability to hire
- enable mass customization
- get control of diverse product configurations
- improve product quality
- increase customer satisfaction
- increase predictability of cost, schedule, and quality

Example Organizational Benefits

Improved productivity
- by as much as 10x

Increased quality
- by as much as 10x

Decreased cost
- by as much as 60%

Decreased labor needs
- by as much as 87%

Decreased time to market (to field, to launch...)
- by as much as 98%

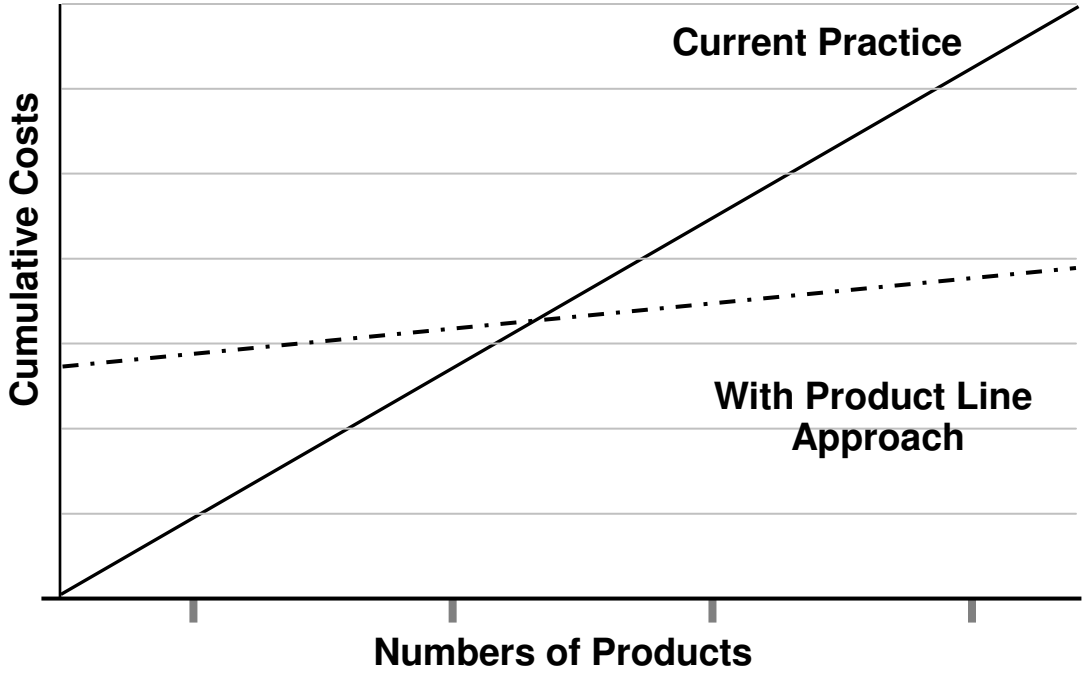
Ability to move into new markets
- in months, not years

Note: Each of the above is based on an individual, documented product line effort.

Costs Of A Software Product Line

Core Assets	Costs
Architecture	Must support variation inherent in the product line
Software Components	Must be designed to be general without a loss of performance; must build in support for variation points
Test Plans, Test Cases, Test Data	Must consider variation points and multiple instances of the product line
Business Case and Market Analysis	Must address a family of software products, not just one product
Project Plans	Must be generic or be made extensible to accommodate product variations
Tools and Processes	Must be more robust
People, Skills, Training	Must involve training and expertise centered around the assets and procedures associated with the product line

Economics Of Product Lines



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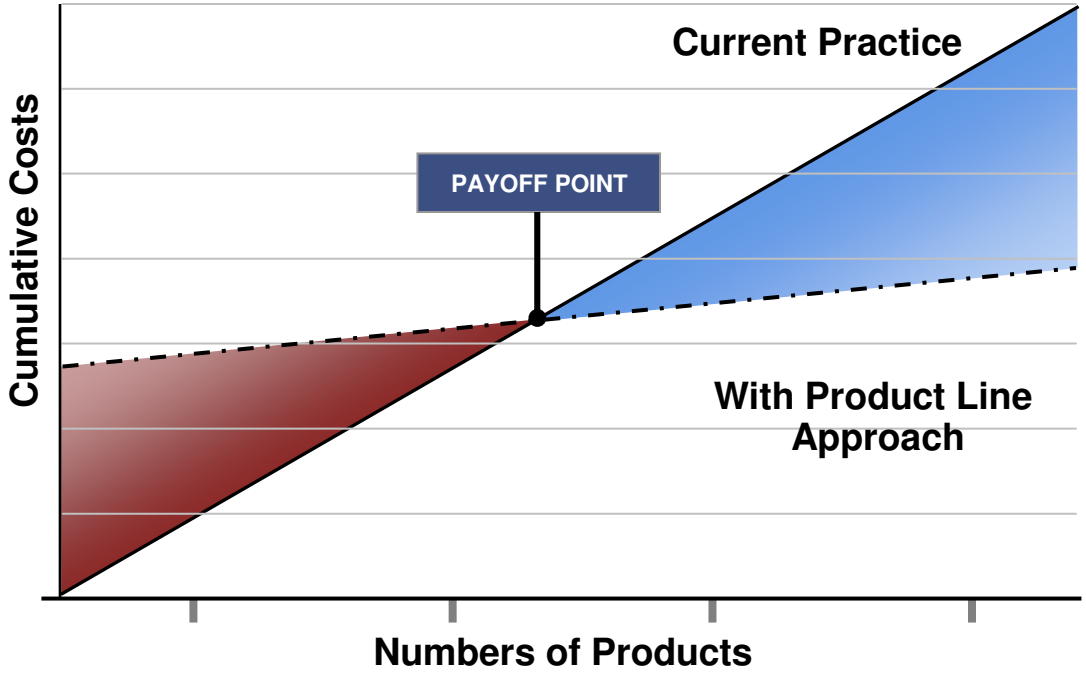
Economics Of Product Lines



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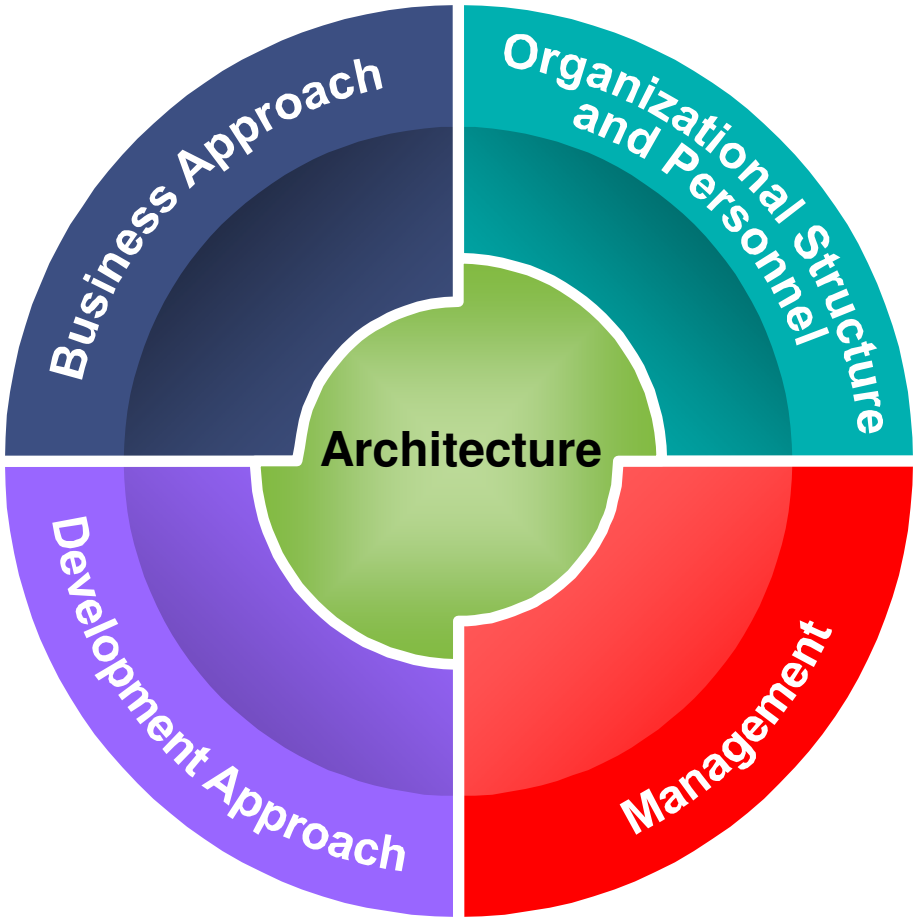
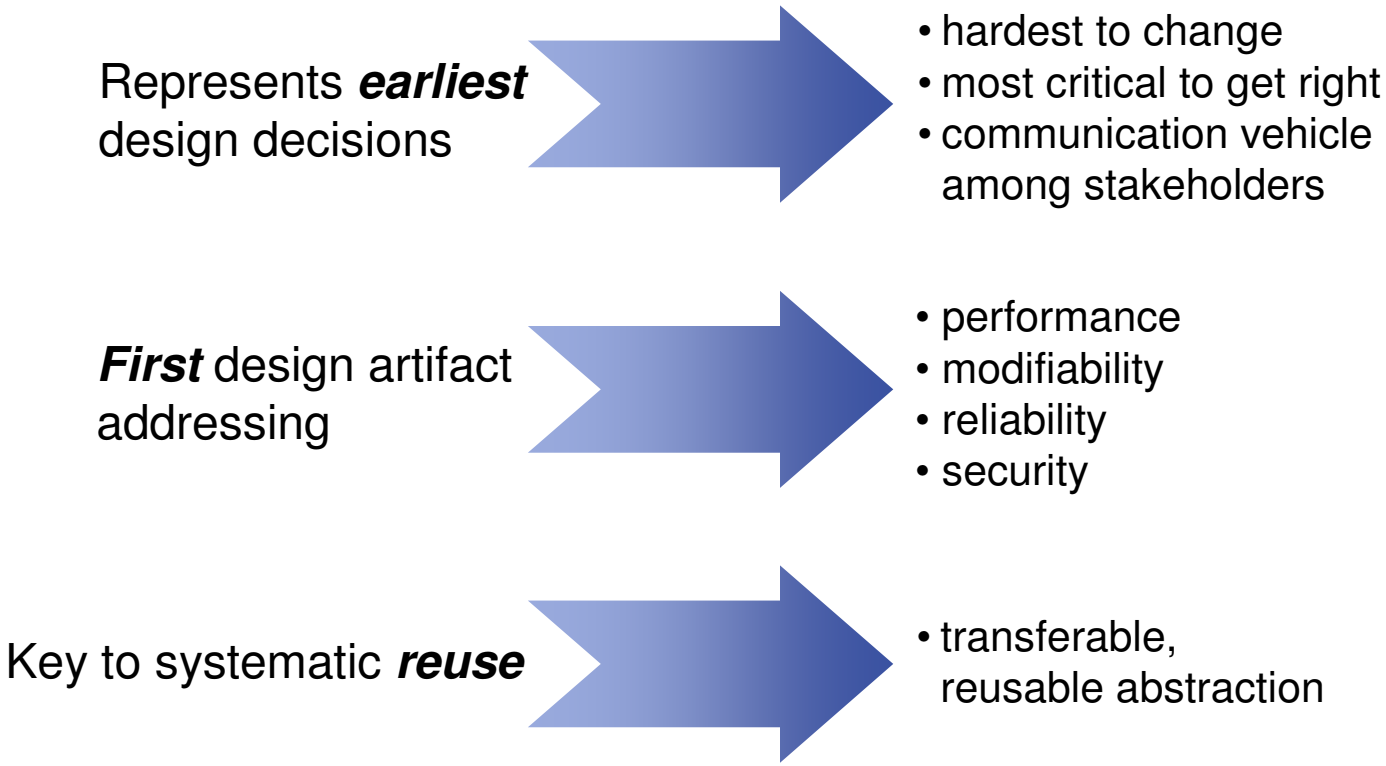
Necessary Changes



The product line architecture is central to success.

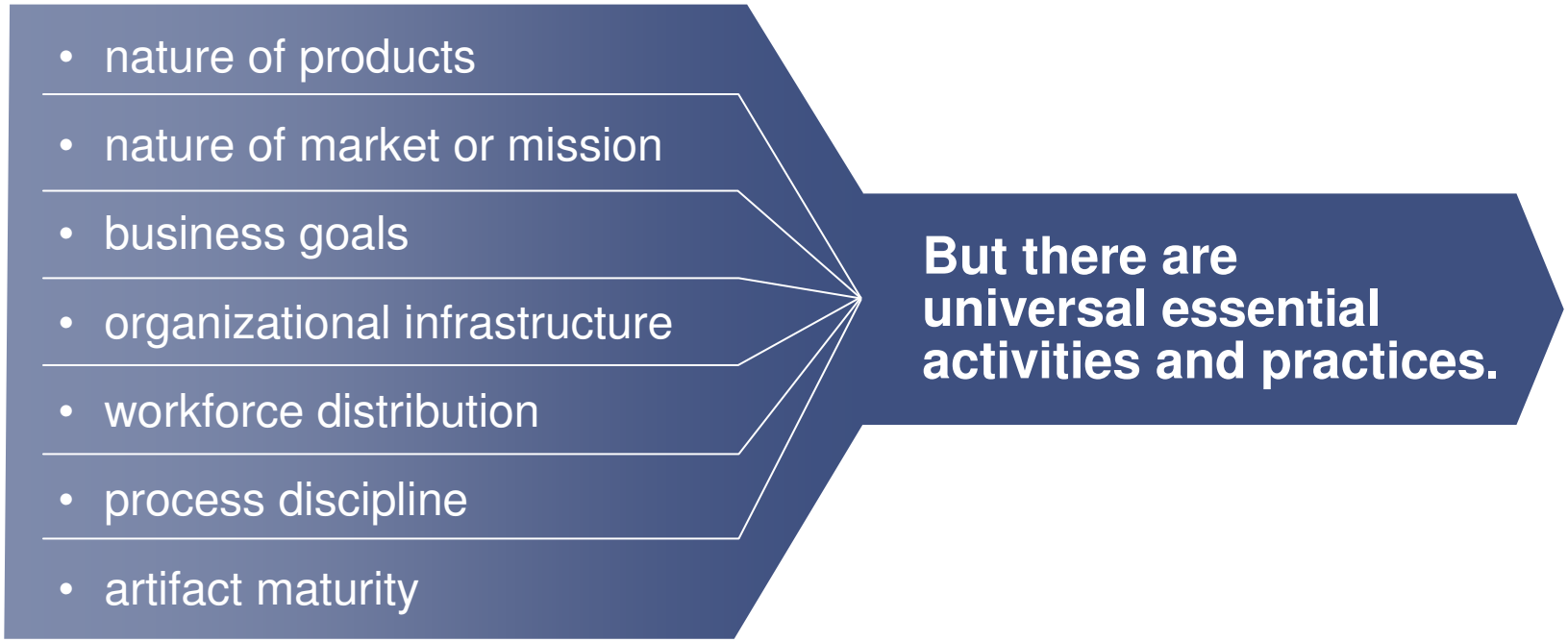
Why Is Software Architecture Important?



The **right architecture** paves the way for system **success**.
The **wrong architecture** usually spells some form of **disaster**.

Product Line Practice

Contexts for product lines vary widely, based on



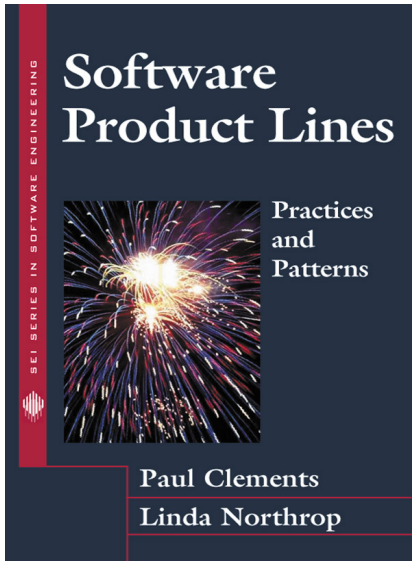
The SEI Framework for Software Product Line Practice[SM]

The SEI Framework for Software Product Line Practice is a conceptual framework that describes the essential activities and twenty-nine practice areas necessary for successful software product lines.

The Framework, originally conceived in 1998, is evolving based on the experience and information provided by the community.

Version 4.0 –
in *Software Product Lines: Practices and Patterns*

Version 5.0 –
http://www.sei.cmu.edu/productlines/framework.html



[SM] Framework for Software Product Line Practice is a service mark of Carnegie Mellon University.

SEI Information Sources

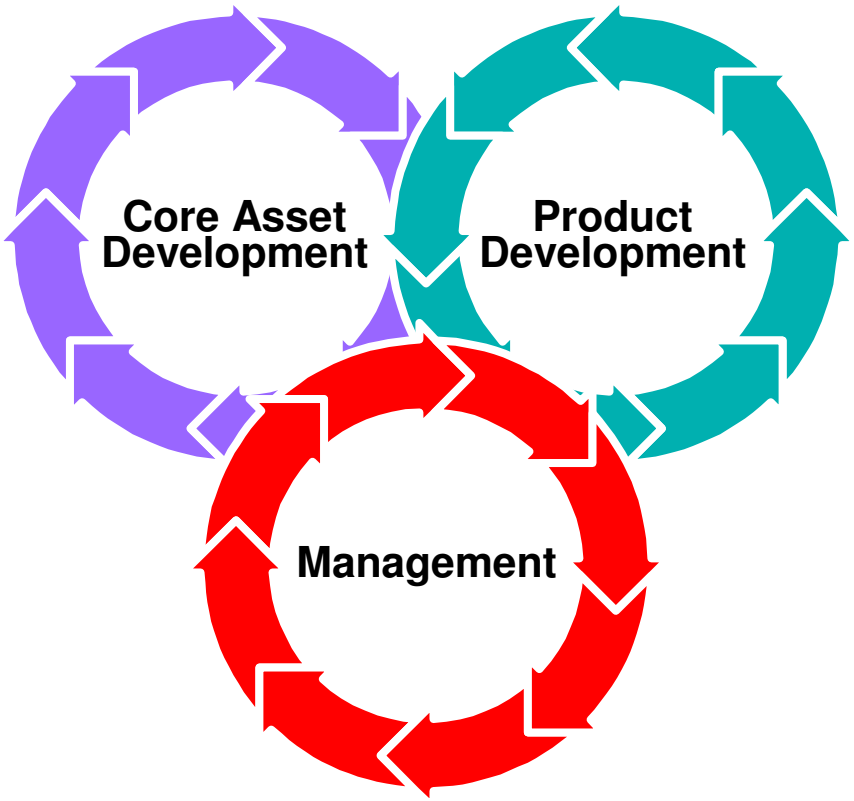
Case studies, experience reports, and surveys

Workshops and conferences

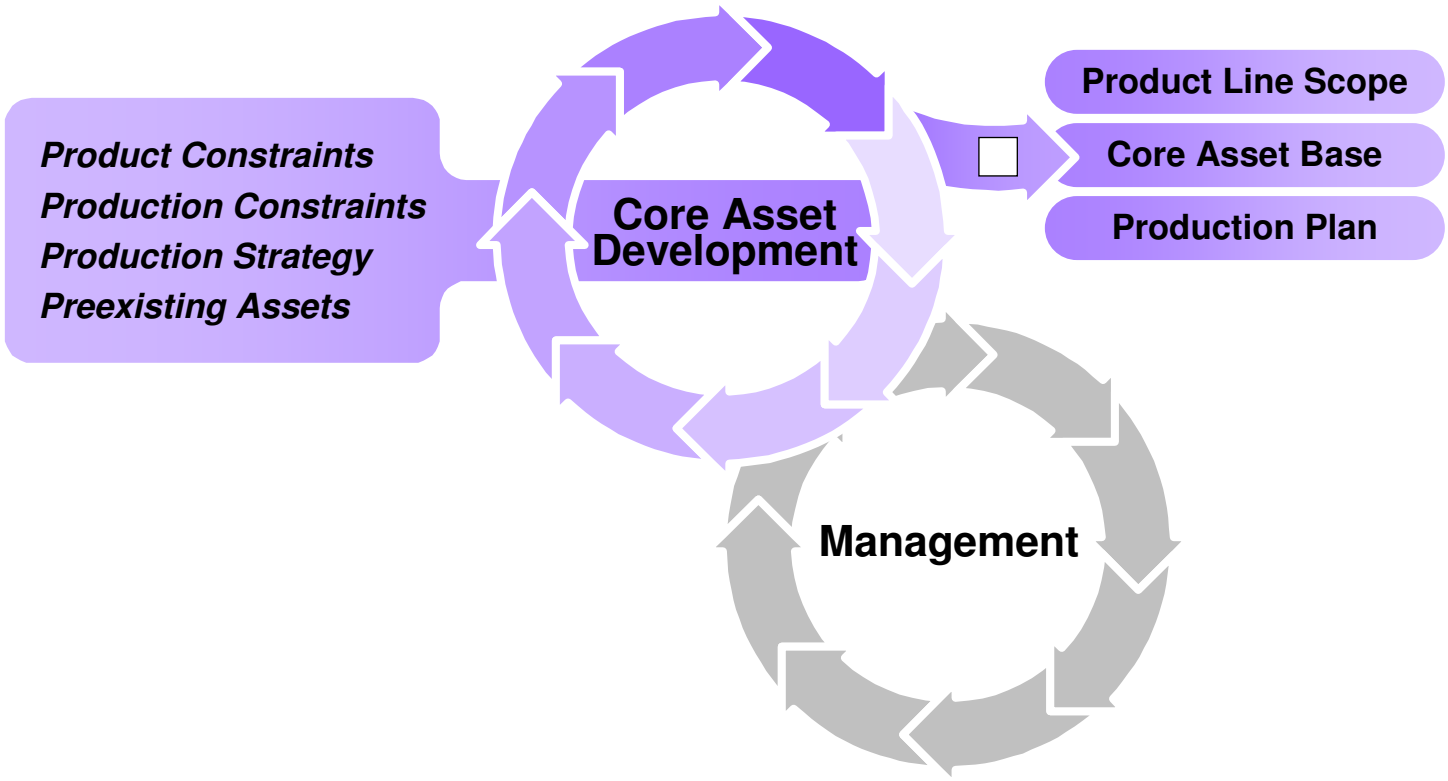
Applied research

Collaborations with customers on actual product lines

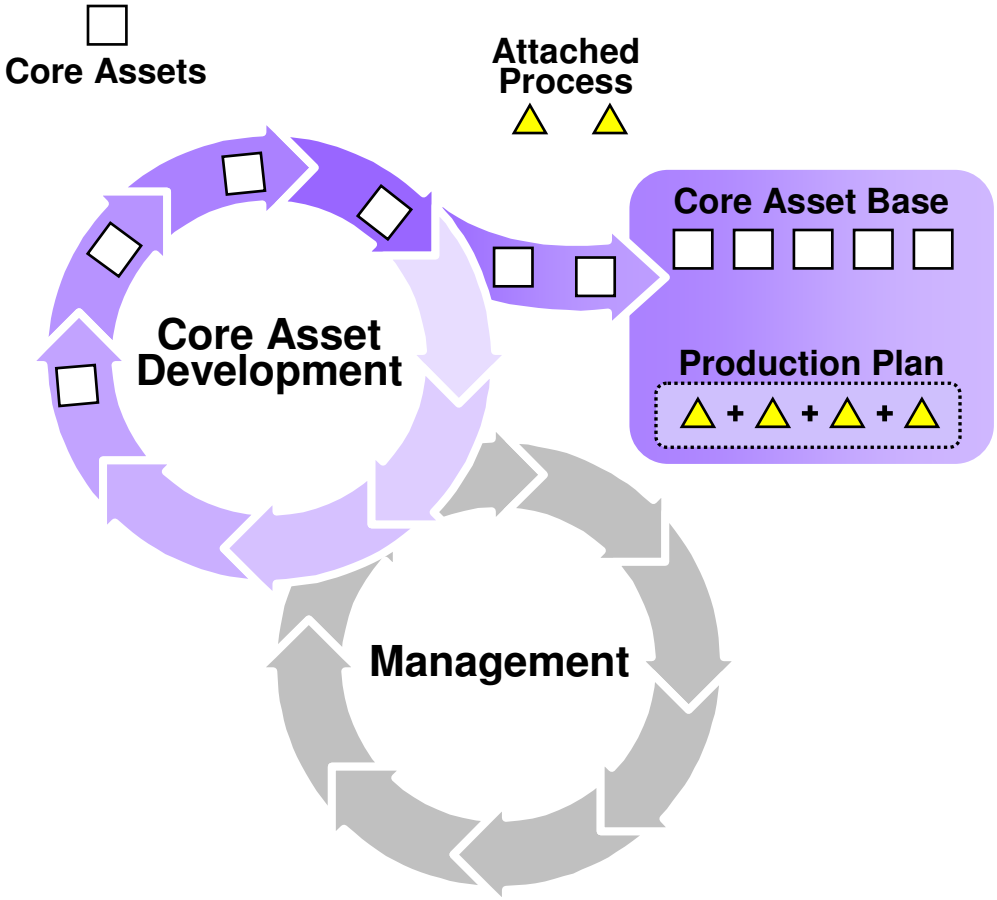
The Three Essential Activities



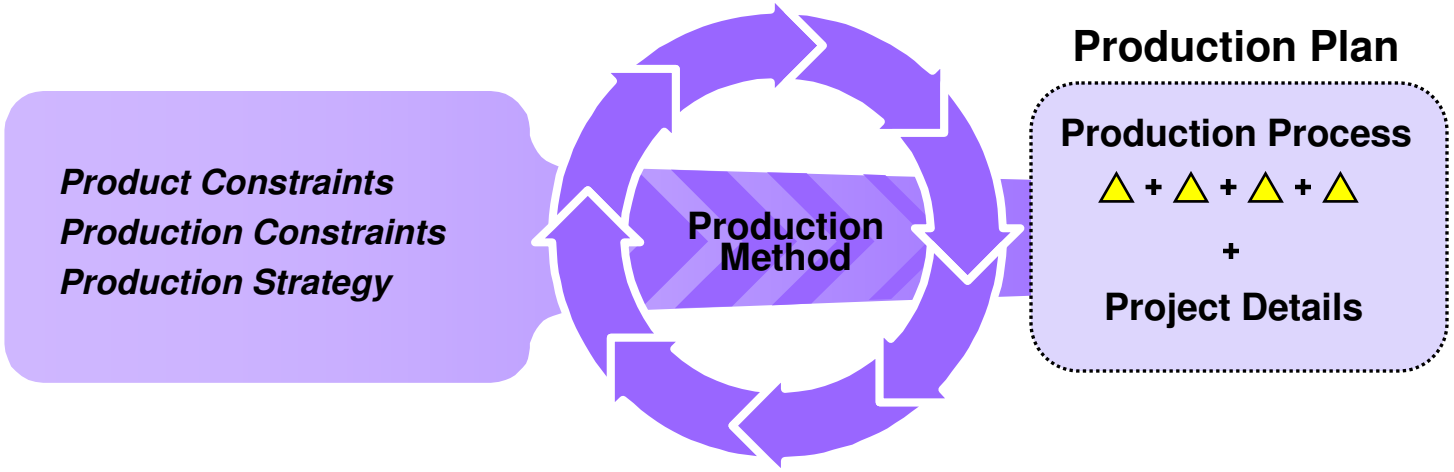
Core Asset Development



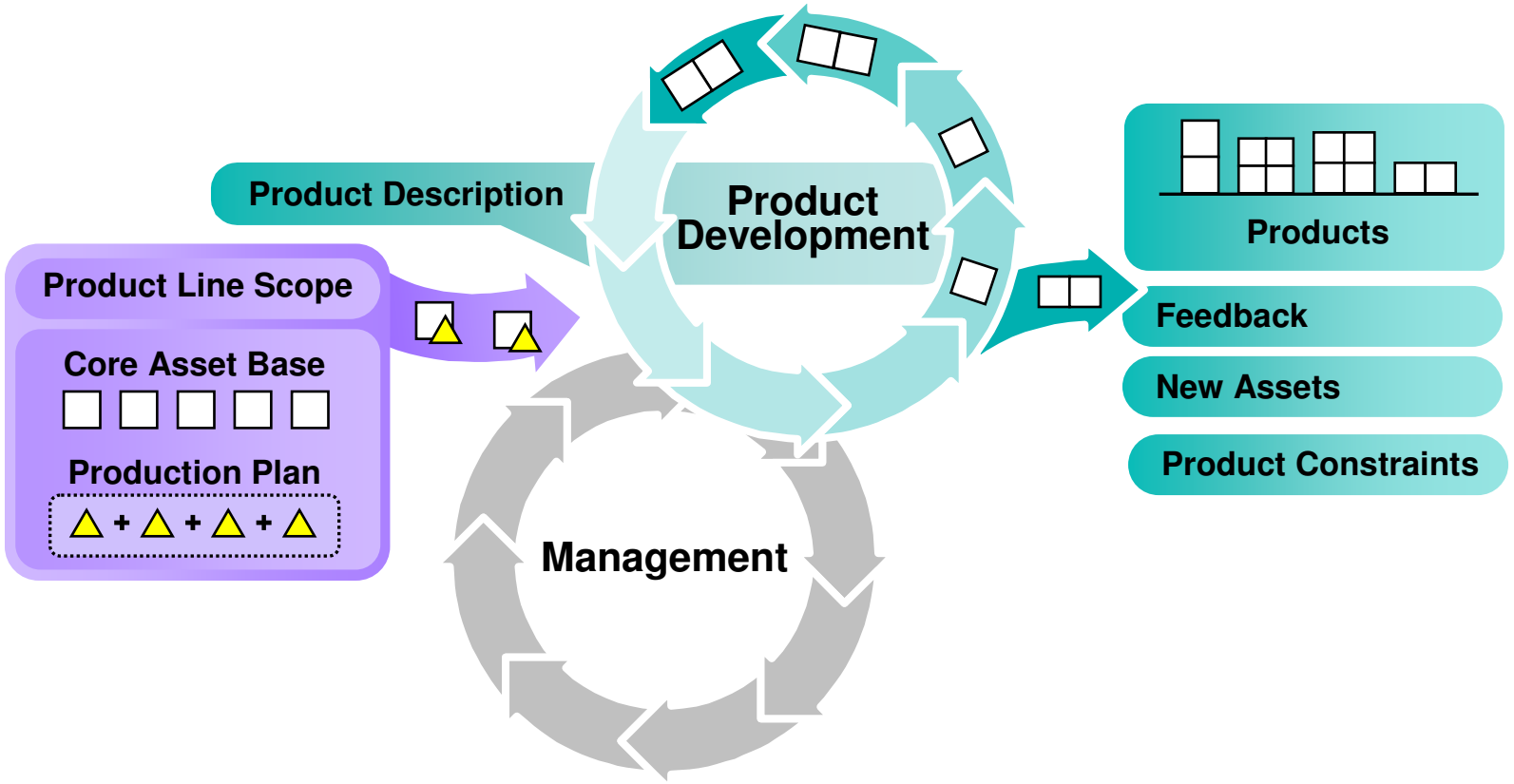
Attached Processes



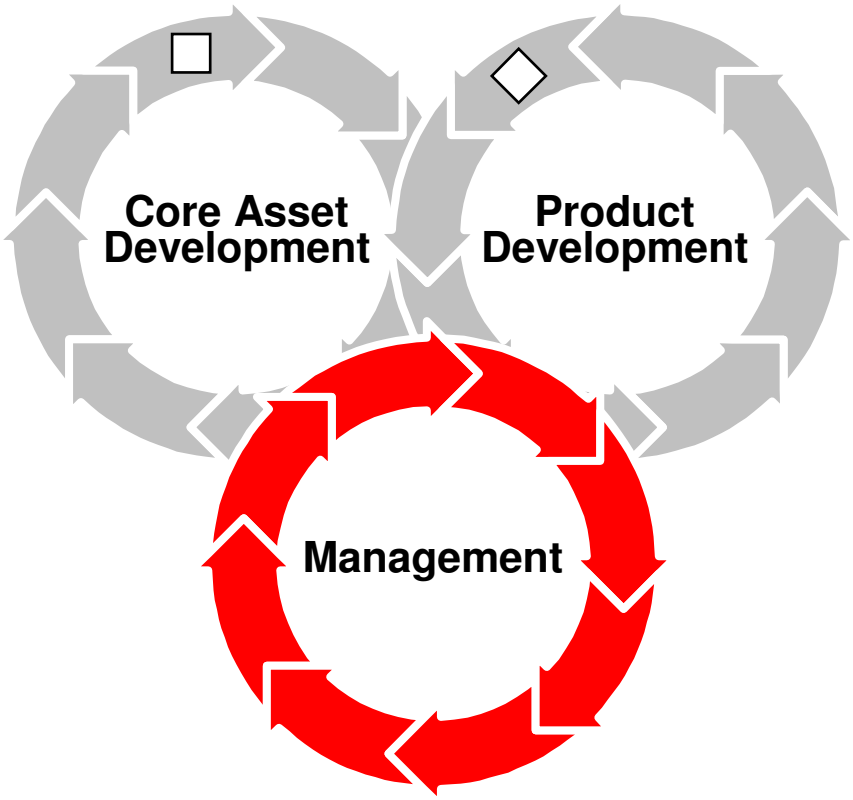
Product Line Production Plan



Product Development

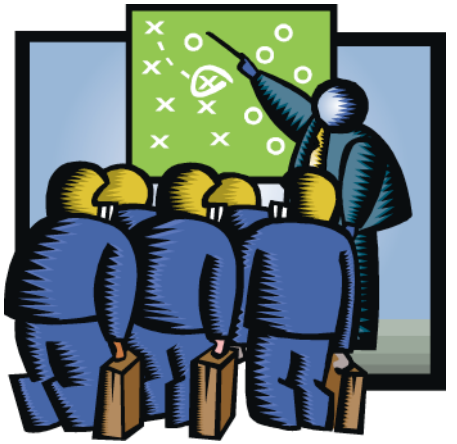


Management



Management

Management at multiple levels plays a critical role in the successful product line practice by



- achieving the right organizational structure
- allocating resources
- coordinating and supervising
- providing training
- rewarding employees appropriately
- developing and communicating an acquisition strategy
- managing external interfaces
- creating and implementing a product line adoption plan
- launching and institutionalizing the approach in a manner appropriate to the organization

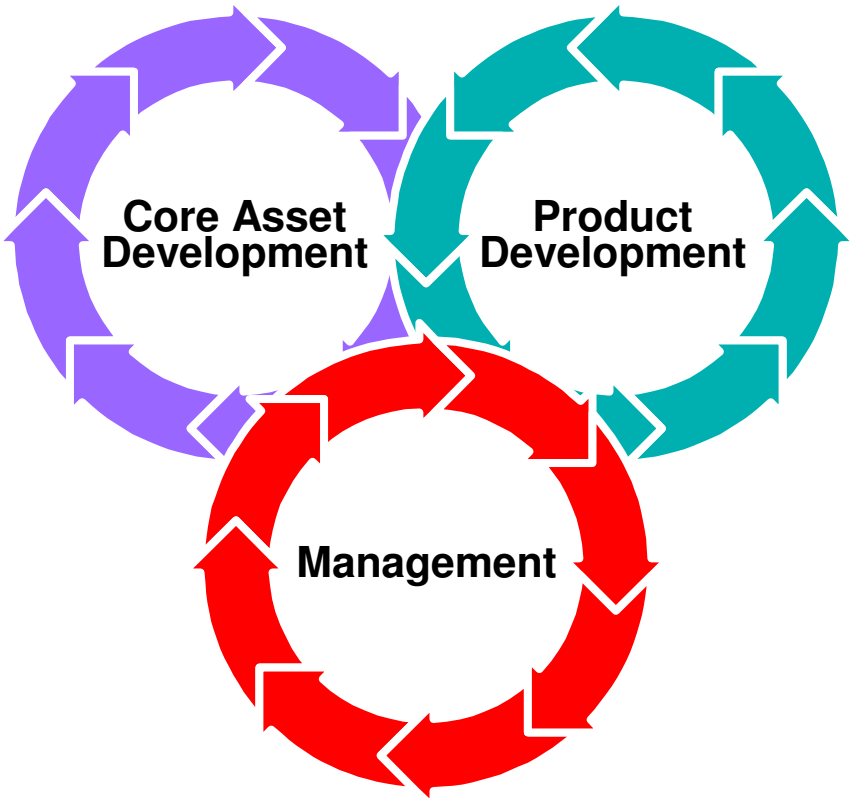
Managing A Software Product Line Requires Leadership

A key role for software product line management is that of champion.

A champion must

- set and maintain the vision
- ensure that the appropriate goals and measures are in place
- “sell” the product line up and down the chain
- sustain morale
- deflect potential derailments
- solicit feedback and continuously improve the approach

Essential Product Line Activities



Each of these is essential, as is the blending of all three.

Different Approaches - 1

Proactive: Develop the core assets first.

- Develop the scope first and use it as a "mission" statement.
- Products come to market quickly with minimum code writing.
- Requires upfront investment and predictive knowledge

Reactive: Start with one or more products.

- From them, generate the product line core assets and then future products; the scope evolves more dramatically.
- Much lower cost of entry
- The architecture and other core assets must be robust, extensible, and appropriate to future product line needs.

Different Approaches - 2

Incremental: In either a reactive or proactive approach, it is possible to develop the core asset base in stages, while planning from the beginning to develop a product line.

- Develop part of the core asset base, including the architecture and some of the components.
- Develop one or more products.
- Develop part of the rest of the core asset base.
- Develop more products.
- Evolve more of the core asset base.
- …

Alternate Terminology

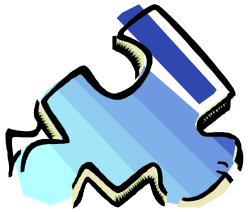
Our Terminology	Alternate Terminology
Product Line	Product Family
Software Core Assets	Platform
Business Unit	Product Line
Product	Customization
Core Asset Development	Domain Engineering
Product Development	Application Engineering

Driving The Essential Activities

Beneath the level of the essential activities are essential practices that fall into practice areas.

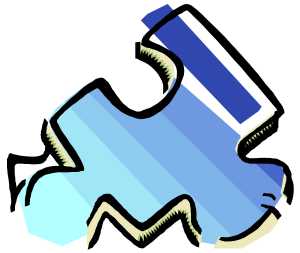
A ***practice area*** is a body of work or a collection of activities that an organization must master to successfully carry out the essential work of a product line.

Practice Area Descriptions

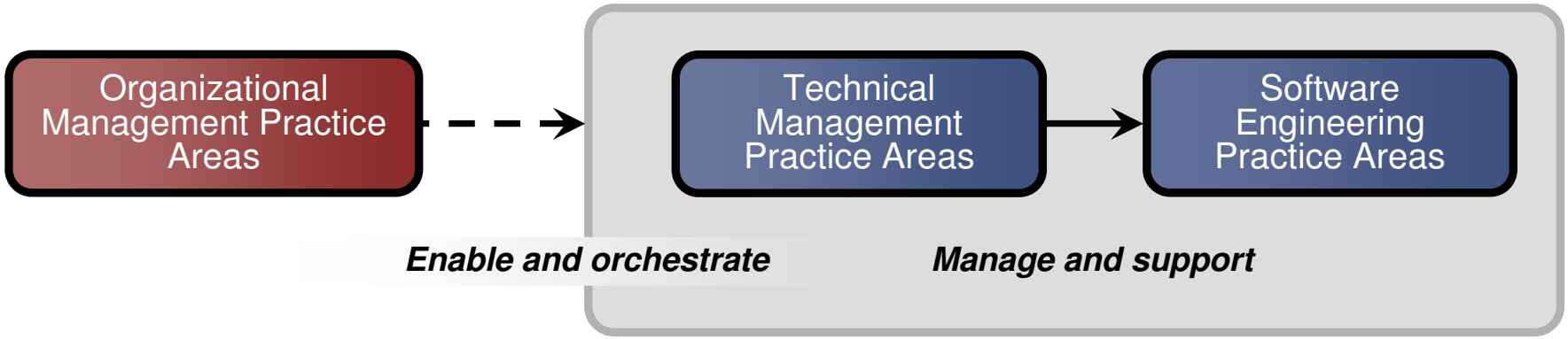


Each practice area is described with

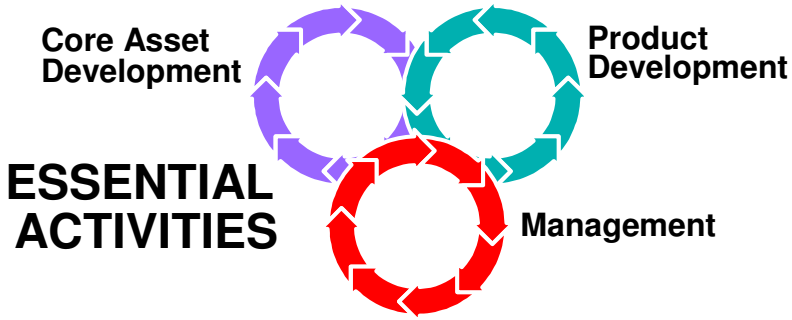
- an introductory description
- aspects that are peculiar to product lines
- its application to core asset development
- its application to product development
- example practices
- associated risks
- further reading



Three Categories Of Practice Areas

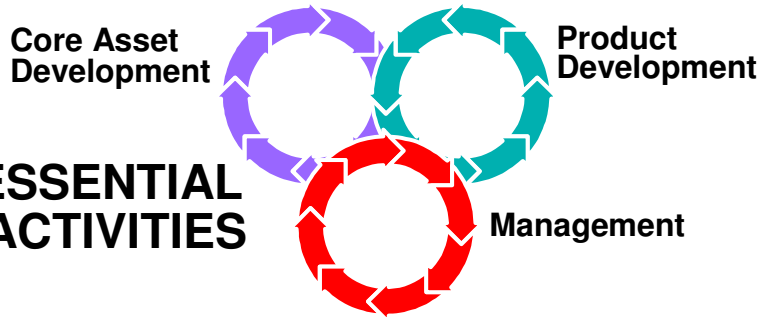


Framework



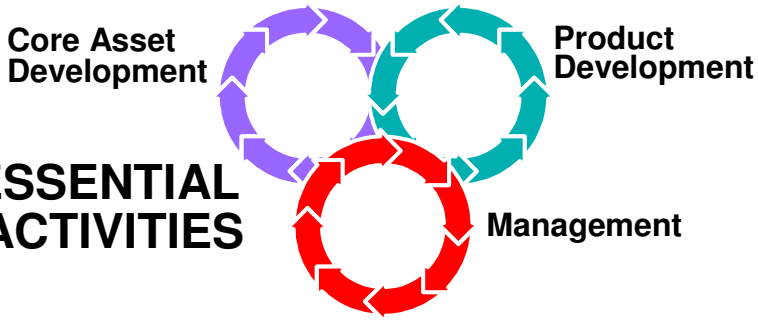
PRACTICE AREAS		
Software Engineering	Technical Management	Organizational Management
Architecture Definition	Configuration Management	Building a Business Case
Architecture Evaluation	Data Collection, Metrics, and Tracking	Customer Interface Management
Component Development	Make/Buy/Mine/Commission Analysis	Developing an Acquisition Strategy
COTS Utilization	Process Definition	Funding
Mining Existing Assets	Scoping	Launching and Institutionalizing
Requirements Engineering	Technical Planning	Market Analysis
Software System Integration	Technical Risk Management	Operations
Testing	Tool Support	Organizational Planning
Understanding Relevant Domains		Organizational Risk Management
		Structuring the Organization
		Technology Forecasting
		Training

Framework Version 5.0



PRACTICE AREAS		
Software Engineering	Technical Management	Organizational Management
Architecture Definition	Configuration Management	Building a Business Case
Architecture Evaluation	***Measurement and Tracking***	Customer Interface Management
Component Development	Make/Buy/Mine/Commission Analysis	Developing an Acquisition Strategy
Using Externally Available Software	***Process Discipline***	Funding
Mining Existing Assets	Scoping	Launching and Institutionalizing
Requirements Engineering	Technical Planning	Market Analysis
Software System Integration	Technical Risk Management	Operations
Testing	Tool Support	Organizational Planning
Understanding Relevant Domains	**Key:** ***New Name and Substantial Change***	Organizational Risk Management
		Structuring the Organization
		Technology Forecasting
		Training

Framework Version 5.0



PRACTICE AREAS		
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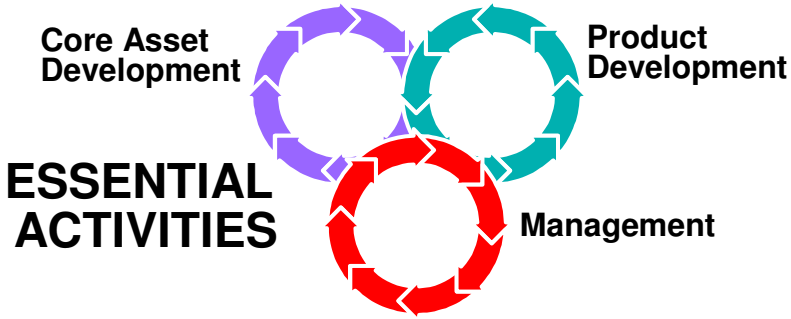
Architecture Evaluation	Make/Buy/Mine/Commission Analysis	**Customer Interface Management**
Component Development	***Measurement and Tracking***	**Developing an Acquisition Strategy**
Mining Existing Assets	***Process Discipline***	Funding
Requirements Engineering	Scoping	Launching and Institutionalizing
Software System Integration	**Technical Planning**	Market Analysis
Testing	Technical Risk Management	**Operations**
Understanding Relevant Domains	**Tool Support**	Organizational Planning
Using Externally Available Software	**Key:**	Organizational Risk Management
	New Name and Substantial Change	**Structuring the Organization**
	Substantial Change	Technology Forecasting
		Training

Dilemma: How Do You Apply The 29 Practice Areas?

Organizations still have to figure out how to put the practice areas into play.

Twenty-nine is a big number.

Help To Make It Happen



PRACTICE AREAS		
Software Engineering	Technical Management	Organizational Management

GUIDANCE			
Case Studies	Patterns	Probe	Curriculum

Case Studies

CelsiusTech – CMU/SEI-96-TR-016
http://www.sei.cmu.edu/publications/documents/01.reports/96.tr.016.html

Cummins, Inc. *Software Product Lines: Practices and Patterns*

Market Maker *Software Product Lines: Practices and Patterns*

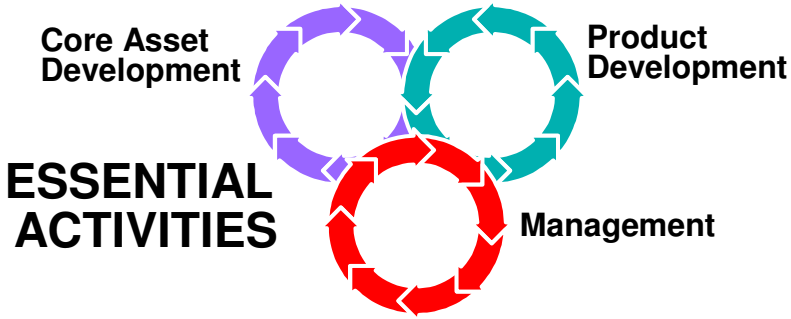
NRO/Raytheon – CMU/SEI-2001-TR-030
http://www.sei.cmu.edu/publications/documents/01.reports/02tr030.html

NUWC – CMU/SEI-2002-TN-018
http://www.sei.cmu.edu/publications/documents/02.reports/02tn018.html

Salion, Inc. – CMU/SEI-2002-TR-038
http://www.sei.cmu.edu/publications/documents/02.reports/02tr038.html

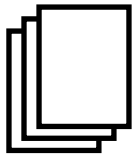
U.S. Army – CMU/SEI-2005-TR-019
http://www.sei.cmu.edu/publications/documents/05.reports/05tr019.html

Help To Make It Happen

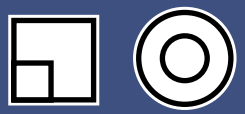


PRACTICE AREAS		
Software Engineering	Technical Management	Organizational Management

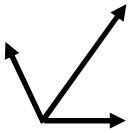
GUIDANCE



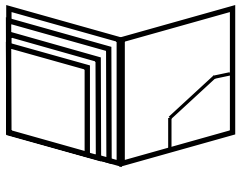
Case Studies



Patterns



Probe



Curriculum

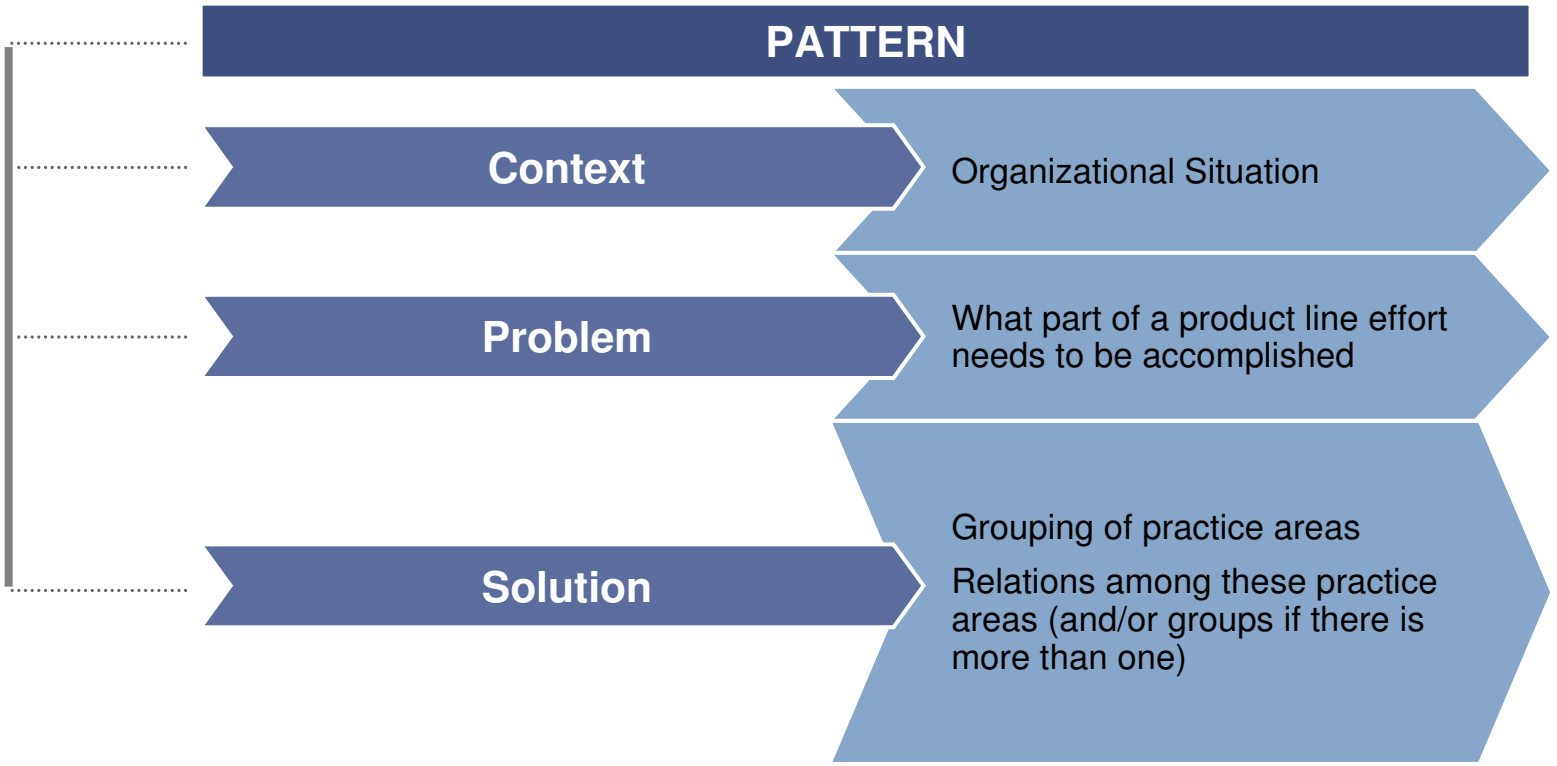
Patterns Can Help

Patterns are a way of expressing common context and problem-solution pairs.

Patterns have been found to be useful in building architecture, economics, software architecture, software design, software implementation, process improvement, and others.

Patterns assist in effecting a divide and conquer approach.

Software Product Line Practice Patterns



What To Build Pattern - 1

Name:

The ***What to Build*** pattern helps an organization determine what products ought to be in its software product line – what products to build.

Context:

An organization has decided to field a software product line and knows the general product area for the set of products.

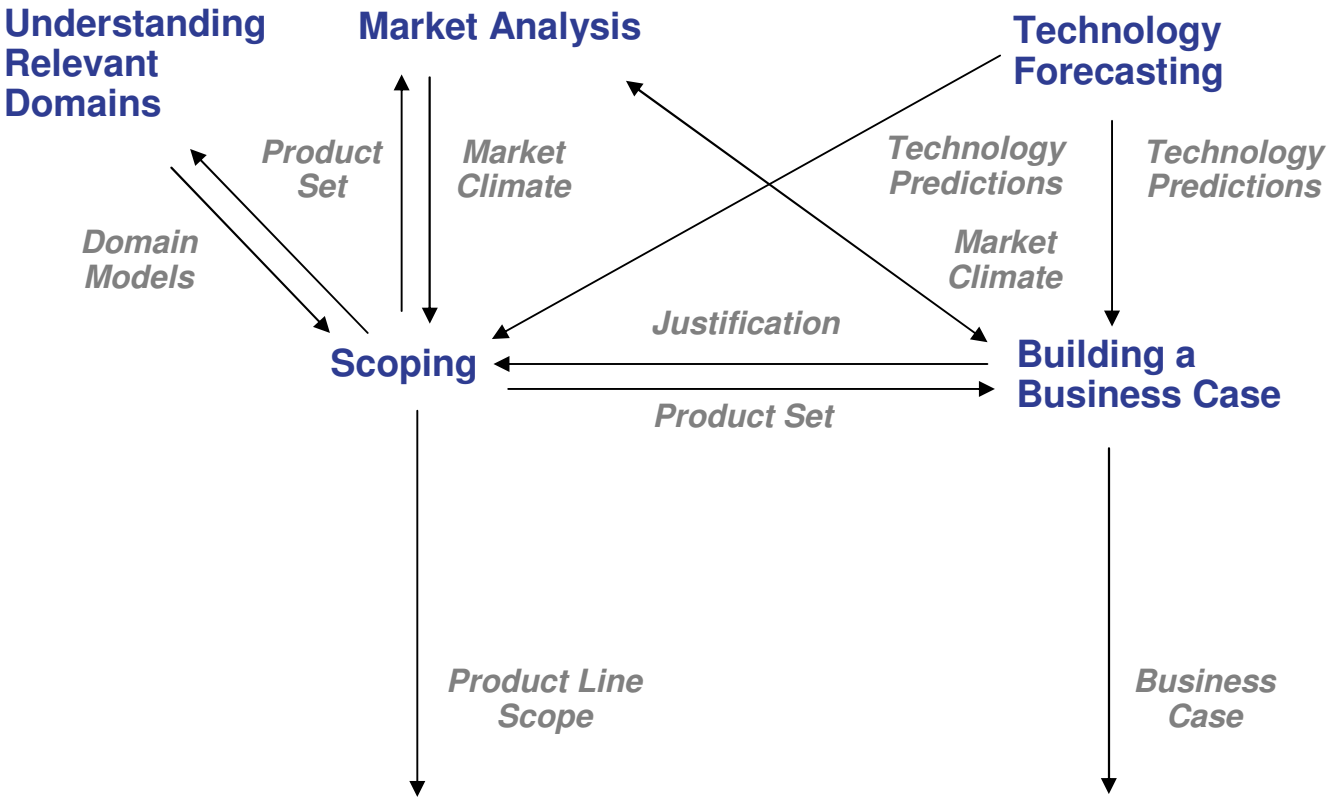
Problem:

To determine what products should be included in the product line

Solution:

Determining what to build requires information related to the product area, technology, and market; the business justification; and the process for describing the set of products to be included in the product line.

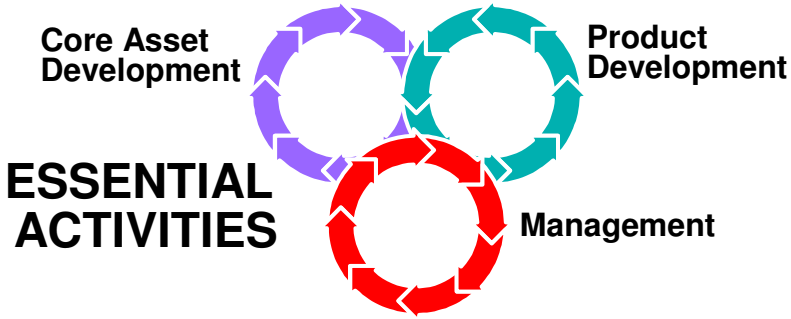
What To Build Pattern - 2



Current Set Of Patterns

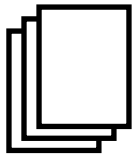
Pattern	Variants
Assembly Line	
Cold Start	Warm Start
Curriculum	
Each Asset	Each Asset Apprentice Evolve Each Asset
Essentials Coverage	
Factory	Adoption Factory
In Motion	
Monitor	
Process	Process Improvement
Product Builder	Product Gen
Product Parts	Green Field Barren Field Plowed Field
What to Build	Analysis Forced March

Help To Make It Happen

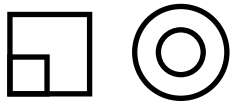


PRACTICE AREAS		
Software Engineering	Technical Management	Organizational Management

GUIDANCE

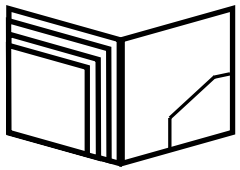


Case Studies



Patterns

Probe



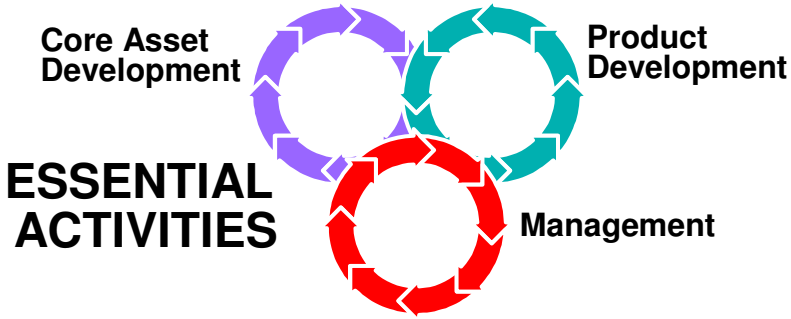
Curriculum

What Is An SEI Product Line Technical Probe (PLTP)?

The SEI PLTP is a method for examining an organization's readiness to adopt or ability to succeed with a software product line approach.

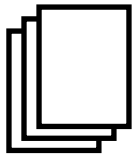
- It is a diagnostic tool based on the SEI Framework for Software Product Line Practice.
- The 29 practice areas are the basis of data collection and analysis.

Help To Make It Happen

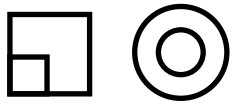


PRACTICE AREAS		
Software Engineering	Technical Management	Organizational Management

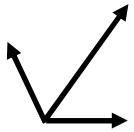
GUIDANCE



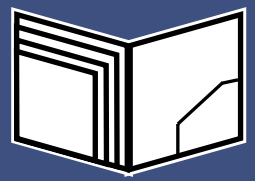
Case Studies



Patterns



Probe



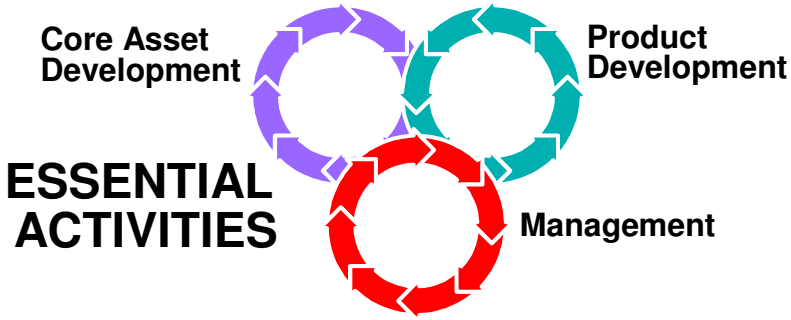
Curriculum

The SEI Software Product Line Curriculum

	Three Certificate Programs		
Five Courses	**Software Product Line Professional**	**PLTP Team Member**	**PLTP Leader**
Software Product Lines	✓	✓	✓
Adopting Software Product Lines	✓	✓	✓
Developing Software Product Lines	✓	✓	✓
PLTP Team Training		✓	✓
PLTP Leader Training			✓
PLTP Lead Observation			✓

✓ **: course required to receive certificate**

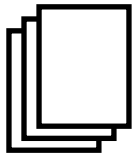
The Entire Picture

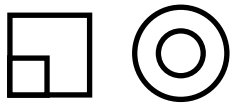


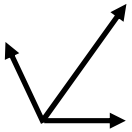
PRACTICE AREAS

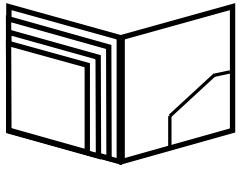
Software Engineering	Technical Management	Organizational Management

GUIDANCE


Case Studies

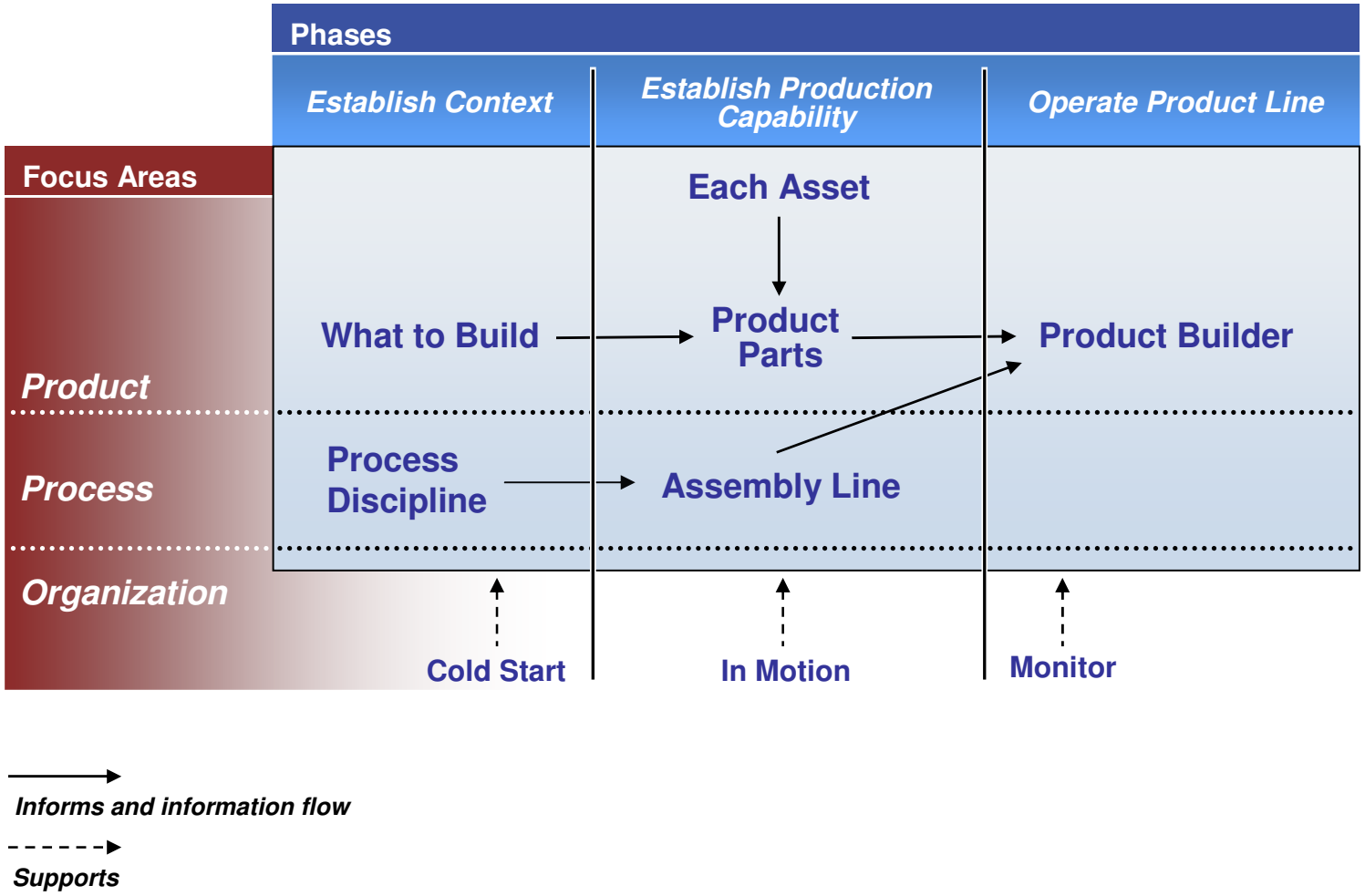

Patterns


Probe


Curriculum

ADOPTION FACTORY

The SEI Adoption Factory Pattern



Associated Practice Areas

	Establish Context	Establish Production Capability	Operate Product Line
Product	• Marketing Analysis • Understanding Relevant Domains • Technology Forecasting • Building a Business Case • Scoping	• Requirements Engineering • Architecture Definition • Architecture Evaluation • Mining Existing Assets • Component Development • Using Externally Available Software • Software System Integration • Testing	• Requirements Engineering • Architecture Definition • Architecture Evaluation • Mining Existing Assets • Component Development • Using Externally Available Software • Software System Integration • Testing
Process	• Process Discipline	• Make/Buy/Mine/Commission • Configuration Management • Tool Support • Measurement and Tracking • Technical Planning • Technical Risk Management	
Organization	• Launching and Institutionalizing • Funding • Structuring the Organization • Operations • Organizational Planning • Customer Interface Management • Organizational Risk Management • Developing an Acquisition Strategy • Training	• Launching and Institutionalizing • Funding • Structuring the Organization • Operations • Organizational Planning • Customer Interface Management • Organizational Risk Management • Developing an Acquisition Strategy • Training	• Measurement and Tracking • Technical Risk Management • Organizational Risk Management • Customer Interface Management • Organizational Planning

Today's Session

Introduction

Product Line Concepts

- What
- Why
- How

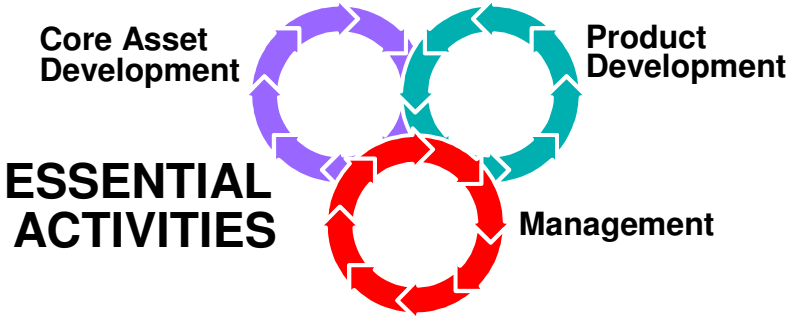
Conclusion

In A Nutshell

Software product lines epitomize the concept of strategic, planned reuse.

The product line concept is about more than a new technology. It is a new way of doing one's software business.

There are essential product line activities and practices areas as well as product line patterns to make the move to product lines more manageable.



PRACTICE AREAS		
Software Engineering	Technical Management	Organizational Management

What's Different About Reuse With Software Product Lines?

- Business dimension
- Iteration
- Architecture focus
- Preplanning
- Process and product connection

At The Heart Of Successful Product Lines

- A pressing need that addresses the heart of the business
- Long and deep domain experience
- A legacy base from which to build
- Architectural excellence
- Process discipline
- Management commitment
- Loyalty to the product line as a single entity

Product Line Adoption and Institutionalization

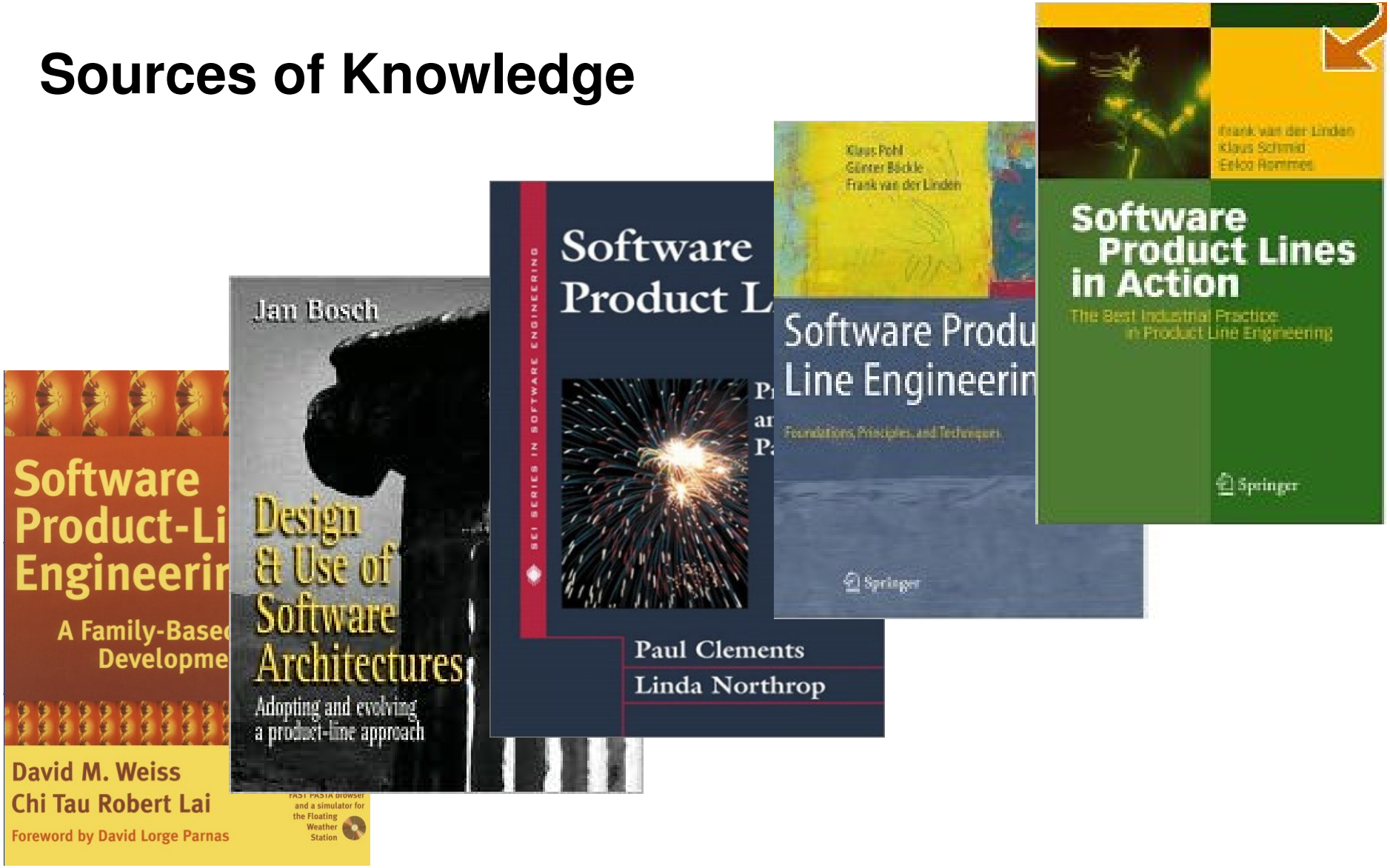
Innovators and early adopters demonstrated the feasibility and the benefits of software product lines:

- CelsiusTech
- Cummins, Inc.
- Hewlett-Packard
- Motorola
- Nokia

The SEI and others have tried to lower the adoption barrier by codifying practices, writing case studies, perfecting methods useful in product line approaches, and engendering a software product line community.

Many organizations are now handsomely achieving their business goals using a software product line approach.

Sources of Knowledge



1999 2000 2002 2005 2007

Summary of SEI Contributions

Models and Guidance

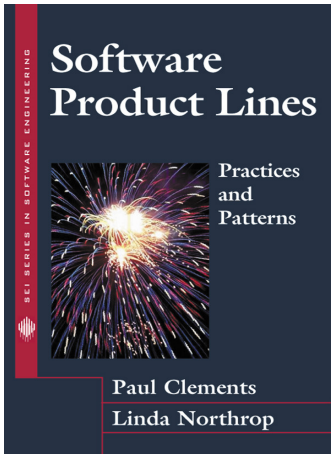
- *A Framework for Software Product Line Practice*[SM]
- *Software Product Line Acquisition: A Companion to A Framework for Software Product Line Practice*
- Product line practice patterns
- Product line adoption roadmap
- Pedagogical product line

Methods and Technology

- product line analysis
- architecture definition, documentation, evaluation (ATAM®), and recovery
- mining assets
- production planning
- Structured Intuitive Method for Product Line Economics (SIMPLE)
- Product Line Technical Probe[SM] (PLTP[SM])
- Product Line Quick Look (PLQL)
- Interactive workshops in product line measurement, variability management, product line management
- Prediction-enabled component technology

Book

Software Product Lines: Practices and Patterns



Curriculum and Certificate Programs

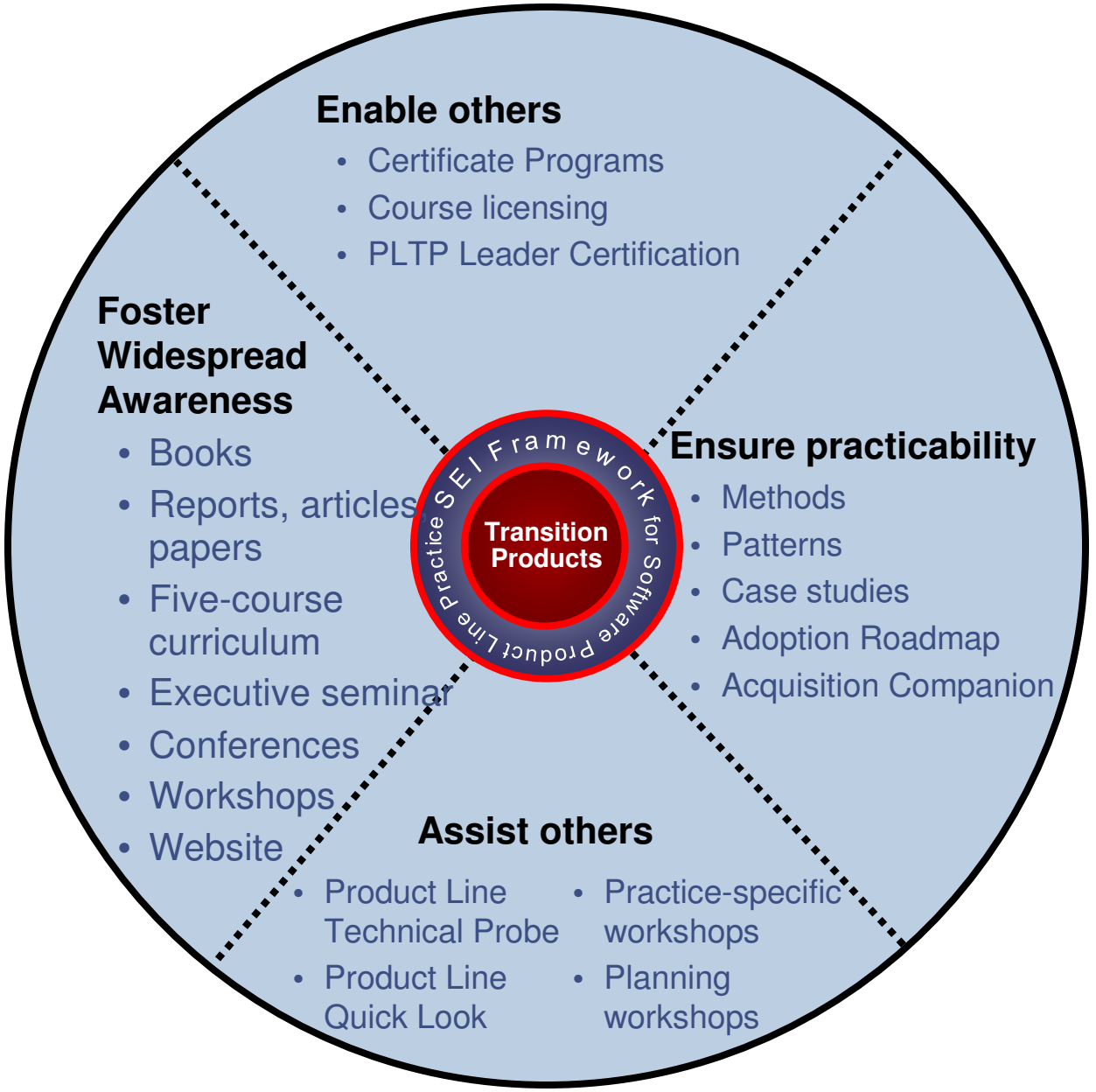
- Five courses and three certificate programs
- Product Line Executive Seminar

Conferences and Workshops

- SPLC 1, SPLC2, SPLC 2004; SPLC 2006; Workshops 1997 - 2008

Technical Reports, publications, and Web site

SEI Transition



Summary

Research in software product lines was inspired by the proven benefits of product line approaches in manufacturing, buoyed by the advent of object and component technology.

The SEI has been a leader in developing a body of knowledge and a set of standard models for software product lines.

Early product line adopters, like Cummins, Inc., are now on second generation product lines that have resulted in even far greater benefits.

Service-oriented and model-driven approaches, as well as developments in collaborative philosophies and environments, are extending the power of product line practice in exciting new ways.

Final Word

If properly managed, the benefits of a product line approach far exceed the costs.

Strategic software reuse through a well-managed product line approach achieves business goals for:

- efficiency
- time to market
- productivity
- quality
- agility

Software Product Lines:
Reuse That Makes Business Sense.

Questions – Now Or Later

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